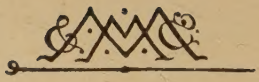
HEALTH READER III

LIFE AND HEALTH

SHELLY AND STENHOUSE

LIFE AND HEALTH

HEALTH READER III.



MACMILLAN AND CO., LIMITED
LONDON · BOMBAY · CALCUTTA
MELBOURNE

THE MACMILLAN COMPANY
NEW YORK · BOSTON · CHICAGO
ATLANTA · SAN FRANCISCO

THE MACMILLAN CO. OF CANADA, LTD.
TORONTO

HEALTH READER III.

LIFE AND HEALTH

WITH CHAPTERS ON
FIRST AID AND HOME NURSING

BY

C. E. SHELLY, M.A., M.D., M.R.C.P.

CONSULTING MEDICAL OFFICER, HAILEYBURY COLLEGE

AND

E. STENHOUSE, B.Sc.

ASSOCIATE OF THE ROYAL COLLEGE OF SCIENCE

PRESENTATION COPY

MACMILLAN AND CO., LIMITED

ST. MARTIN'S STREET, LONDON

1911

GLASGOW : PRINTED AT THE UNIVERSITY PRESS
BY ROBERT MACLEHOSE AND CO. LTD.

PUBLISHERS' NOTE

THE Committee of the Medical Profession formed for the furtherance of the Teaching of Hygiene and Temperance in Elementary Schools remarked in a recent Memorandum on the subject to the President of the Board of Education: "It is now fully recognised that Teaching in Hygiene and Temperance in Public Elementary Schools is essential for the development of the well-being and happiness of the Nation at large."

The Board of Education has on several occasions directed the attention of Teachers in these schools to the importance of such instruction. In the Code for 1909 it is stated that the work in Hygiene and Physical Training should include "instruction adapted to the ages and sexes of the scholars in the elementary rules of personal health, particularly in respect of food, drink (including alcohol), clothing, cleanliness, and fresh air; and careful cultivation of a correct posture at writing and other lessons." Similarly, in one of its recent reports the Board insists on the

same point: "Of great importance . . . is the desirability now very widely recognised that opportunity should be found, in connection with the curriculum in elementary schools, for imparting to the children who are destined to become the mothers and fathers of the race, the broad principles of healthy living."

This book, and the companion volumes already published, have been prepared to meet the requirements of classes in which such instruction is given. The present book is designed for use with children of 12 to 14 years of age; the second volume will be found suitable for pupils of 10 to 12 years of age, and the first for those of 9 to 10.

Great care has been taken to combine accuracy with simplicity, and it is believed that children will read the lessons with interest and profit. The illustrations have been selected with the object of increasing the attractiveness of the book from the pupil's point of view.

The scheme and scope of the books have been inspired by the suggested courses of work issued by the Committee of the Medical Profession, though the order and method of treatment represent the results of the authors' experience alone.

CONTENTS

LESSON		PAGE
I.	Plants as our Fellow-Creatures	1
II.	How Plants Feed	8
III.	Breathing and Reproduction of Plants	13
IV.	Plant and Human Physiology Compared	19
V.	The General Arrangement of Human Bones	25
VI.	The Bones and their Growth	31
VII.	The Muscles	36
VIII.	The Classes of Foods	41
IX.	Typical Foods	46
X.	The Selection and Preparation of Food	51
XI.	The Digestion of Food	56
XII.	The Absorption and Uses of Food	61
XIII.	Foods to be Avoided	66
XIV.	Water	70
XV.	The Sources of Drinking Water	76
XVI.	Beverages	82
XVII.	Non-Nourishing Drinks	86
XVIII.	Tea and Coffee	90
XIX.	Alcoholic Beverages	95
XX.	Respiration	99
XXI.	The Organs of Respiration	104
XXII.	Other Uses of Breathing	110
XXIII.	The Dangers of Insufficient Ventilation	116

LESSON		PAGE
XXIV.	The Cleansing of the Tissues	121
XXV.	The Cleansing of the Tissues (*Continued*)	126
XXVI.	The Duties of the Blood	130
XXVII.	The Heart	136
XXVIII.	Arteries and Veins	141
XXIX.	The Nervous System and its Uses	145
XXX.	Society as an Organism	152
XXXI.	The Responsibility of the Individual	156

PART II.

FIRST AID AND HOME NURSING

XXXII	The Principles of First Aid in Accidents, Injuries, and Illness	161
XXXIII.	Wounds, Cuts, Bruises, and Sprains	168
XXXIV.	Fractures and Dislocations	176
XXXV.	Burns and Scalds: Bites and Stings: Foreign Bodies in Eye, Ear, Nose, Mouth, and Throat	185
XXXVI.	Fainting, Sickness, Fits, Choking, Hiccough, Nose-Bleeding, Bleeding from the Stomach and from the Lungs	192
XXXVII.	Drowning: Suffocation, by Coal Gas, Sewer Gas, and Well Gas: Electric Shock: Sunstroke	198
XXXVIII.	Poisons	203
XXXIX.	Early Signs of Illness: Emetics, Poultices, and Fomentations	205
XL.	Things to Remember in Tending the Sick	214
	Brief Directions for Use in Connection with the Common Poisons	227
	Index	233

HEALTH READER. III.

LESSON I

PLANTS AS OUR FELLOW-CREATURES

THERE are many good reasons for the great interest which human beings have always found in plants. The first and by far the most important of these is the fact that plants directly or indirectly supply us with all our food. It is natural that civilised man in every age has paid great attention to a subject affecting his livelihood so closely, and has studied with care the conditions under which plants may be grown with the greatest success.

But even if our race were freed from all anxiety about its supply of food, plants would still be found worthy of careful study. The knowledge that they are living things with lives very similar in many respects to our own would make us curious to learn as much of them as possible.

This must have been the idea in the mind of the famous Lord Herbert of Cherbury when he wrote, "I conceive it is a fine study and worthy of a gentleman to be a good botanique, that so he may know the nature of all herbs and plants, being our fellow-creatures."

It is because plants are our fellow-creatures that we can learn from them many facts which will help us in the wise ordering of our own lives. In the first few lessons of this book we shall study plants a little from this point of view. It will soon become evident that they are like us in many respects, and also that, like ourselves, they can remain healthy only by following certain rules of life. Further than this, we shall find that some of the most important of these rules are the same for them as for ourselves.

The first thing to realise is that plants are very much alive. Evidence of this is not far to seek; every garden, field and hedgerow is full of it. A tiny seed showing no sign of life, and in appearance perhaps very like a grain of gravel, drops to the ground. A grain of gravel left undisturbed for a year is but a grain of gravel still, for it is lifeless. But by the end of a year the seed is no longer a seed. In the meantime it has sprouted (Figs. 3 and 6); one part has pushed itself as a root into the soil, feeling its way among the stones. Another part called the stem has raised itself into the air and the light of day, perhaps with the help of some support which it has found and clasped.

The stem has also put out spreading green leaves. The tiny seed has grown into a plant of many thousand times its original size and weight, and inconceivably more complex.

Flowers also may have appeared on the stem, have bloomed for a time and then faded, leaving in their places pods or some other form of fruits. Inside these are to be found seeds—perhaps many hundreds altogether—each resembling the one which in the previous

spring was the starting-point of all this wonderful activity.

This is but the bare outline of what can be seen year by year in the commonest weeds of the wayside;

Fig. 1.—A Sycamore Tree.

but no one can possibly watch, even carelessly, such changes taking place without feeling sure that a plant is full of vigorous life. And the more closely plants are studied, the more does it become clear not only that they feed, breathe, grow, and increase in numbers, but also that they can, as it were, feel what their

surroundings are like and behave accordingly, so as to avoid many dangers and to take advantage of any good opportunities which they may meet. It is because plants have these powers that we know they are living things, and, like all other living things, our fellow-creatures.

FIG. 2.—Four Sycamore Fruits. Each contains a seed at the thick end. (½ the natural size.)

As the first appearance of life is usually to be seen when the seed sprouts, it will be interesting to learn, at this point, what signs of the future plant and its needs are to be found in a seed.

The most important thing that a seed contains is a baby-plant. In some kinds of seeds this is very tiny, even when the seed is ripe, but in others it may be more than an inch long. Whatever its size may be, this baby-plant is always simple as compared with the full-grown plant which it will become later. In fact it is not easy to find anything in it besides a little root, a little stem, and one or more very simple leaves.

FIG. 3.—Young Sycamore Plant removed from the seed and uncoiled. The two seed-leaves are marked *cot*. (Natural size.)

These things may be seen very nicely in a sycamore seed which has been soaked in water until it is soft. Then when the skin or seed-coat has been carefully peeled off, the parts of the little sycamore plant may be uncoiled and examined. Even at this early stage

it has a little root ready for growing into the soil, a little stem ready for growing upwards, and a pair of green leaves ready to spread themselves out to the light and air (Fig. 3).

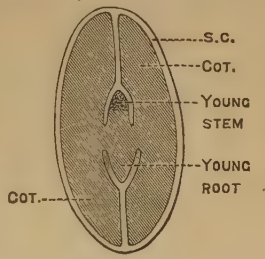


FIG. 4.—Diagram of a Bean Seed cut through to show the parts of the young plant. *s.c.*, seed-coat; *cot.*, swollen seed-leaves. (Natural size.)

The same parts are really present in a bean seed too, but in this case the two seed-leaves are so swollen with food that they are not at all like leaves in appearance. The food has been packed away in the leaves by the bean-baby's mother in order that when the young bean plant begins to grow it will for some time not need to use its strength in the work of making food. In this respect the young bean plant is more fortunate than the young sycamore, which has hardly any food ready prepared, and so must learn to feed itself almost from the first. Many other seeds are like the bean in having the seed-leaves of the young plant packed with food.

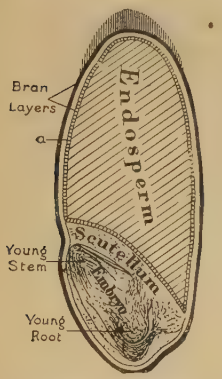


FIG. 5.—Grain of Wheat cut along its length to show the store of food outside the young plant or embryo. (Magnified.)

There are a great many seeds, however, which contain a store of food quite outside the young plant, and yet so close at hand that the plant can make use of the food whenever it is hungry. Food of this kind is known as endosperm. The wheat

seed (Fig. 5) is an example of a seed containing endosperm besides a baby-plant. Here again, the use of the food is to relieve the young plant for a time from the labour of earning its own living, so that it may give all its energies to growing big and strong.

These baby-plants in seeds may be compared to a man starting on a journey. In this case it is the journey of life. The young sycamore plant is like a man beginning his journey hungry and without a store of provision. He will be compelled to stop and work to obtain food before he has gone very far. The young bean plant is like a man starting on a journey after eating a good meal, but without taking any other food along with him; while the young wheat plant is like a man beginning his journey with a great parcel of food on his shoulder. Both the young bean and the young wheat will be able to travel for some distance on the journey of life before they will need to work for food.

If seeds are put into suitable soil at the proper time they will sprout, as we know. Such sprouting, or the early growth of a plant from a seed, is best called germination.

When a seed germinates, the little root of the baby-plant in the seed grows longer; its end comes out through a hole in the seed-coat and makes its way downwards into the soil. Other roots soon appear, often growing out in large numbers from the sides of the first. They push themselves in all directions between the particles of soil, and obtain a firm hold on the ground, while at the same time they are able to take up water and substances dissolved in it from the soil.

In the meantime the little stem has also become larger, and soon it pierces the earth and grows up to the light and air. What of the tiny leaves which are also present in the seed? In very many cases they grow upwards with the stem, and unfold themselves as soon as they are above ground (Fig. 6). But where

FIG. 6.—Two early stages in the growth of a Sycamore Seedling. The first pair of foliage leaves are marked *fol* in the left figure. (Natural size.)

much food is stored in the seed there is no great need for leaves above ground at first, and in such cases the seed-leaves may stay under the soil, doing good work there by making the stored food fit for use.

Seeds will not behave in this way unless they are under healthy conditions. To be able to germinate, they need moisture, fresh air and a certain warmth. So long as they are either kept dry, or planted where the air cannot reach them easily, or put in a place which is very cold, they will show no signs of life; and at last, if in any of these ways they are prevented from germinating, they will die.

LESSON II

HOW PLANTS FEED

Both when it is a sprouting seed and afterwards, a plant is able to move by its own power without being pushed or pulled by anything outside. It forces its roots through the soil; it raises its stem, in many cases, to a great height above the ground; and often it feels about with threads called tendrils for some support to which it may cling.

These and other facts of a similar kind would in themselves be enough to convince us that a plant was alive, but there are other reasons besides these for thinking so. One is, that when a plant is very active, it is so much warmer than its surroundings that the difference can be detected with a thermometer.

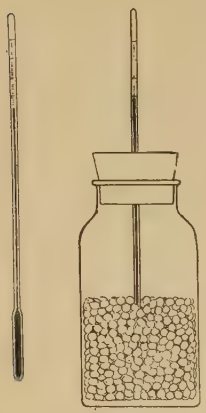


Fig. 7.—Experiment to show the warmth of germinating seeds.

All that is needed to show this is to keep some seeds warm and moist until they begin to sprout; to put enough in a bottle to make it about one-half full, and then close the bottle with a cork through which a thermometer has been pushed so that the bulb of the thermometer is covered by the sprouting seeds. After a little while the mercury in this thermometer will be found slightly

higher than the mercury in a similar thermometer outside the bottle. Germinating barley grains do very well for this experiment.

There are not many times in the life of a plant when it is so vigorous as in those early stages called sprouting or germination, and it cannot be expected to be always so distinctly warmer than the lifeless things near it. And yet it is likely that some parts of a living plant are at all times very slightly warmer than the surroundings, although we may not be able to prove it at present. We know that living human bodies are warmer than their surroundings because a slow combustion is taking place in them, and we have good reason for thinking that it is this combustion or burning which gives our bodies all their wonderful powers.

It seems, therefore, that a living plant is like a living animal or man not only in being able to move, but also in always burning away. Evidently, then, a plant must resemble an animal in still another respect: it must feed, and so replace what has been burnt, or it will die.

During its life an ordinary plant feeds in two different ways. When it is germinating it lives on food which its parent stored up in the seed; but when it has finished this seed-food it must make its own. As might perhaps have been expected, the food put aside in the seed for the use of the baby-plant is very rich and nourishing. Men learnt this long ago, and ate seeds for the sake of the food in them, though it had been really prepared for the little plants.

It is interesting to consider how many of our most valuable foods are still obtained from seeds. Our bread is made from the endosperm (which we call flour) stored in the seeds of certain kinds of grass known as wheat. Other kinds of grasses which store in their seeds food meant for the use of the baby-plants are rye, oats, barley, maize and rice; this food also we eat. Peas, beans and lentils are also seeds; they contain food which many human beings use as a change from meat. The kernels of nuts are other seeds full of good food, and from many of them oil can be obtained which is so good and wholesome that strict vegetarians use it instead of butter.

No one thinking of these things can help being struck by the great similarity in the food needed by human beings and that needed by young plants. In each case the food is necessary to make good the loss of material which the combustion of the living substance causes.

A young plant often grows to a height of many inches before it has used up all the food contained in the seed from which it sprouted. The food is chiefly required where the growth is most rapid, that is, at the end of the stem and the tips of the roots, so that it has to be carried some distance before it is used. It is carried, dissolved in a watery fluid called sap, through fine pipes.

But much of this stored food is at first in such a form that the sap cannot dissolve it. Starch is one of the commonest food materials in seeds, and starch will not dissolve in the sap. So long as the starch remains starch, it is useless, because it cannot

leave the seed, however much the other parts of the plant may need it. What is to be done?

Fortunately for the plant, a curious substance called diastase is formed as the seed germinates, and diastase has the remarkable power of changing starch into sugar. Now sugar dissolves quite readily in the watery sap, so that it can be carried rapidly to all parts of the plant which need it. The change of a food into a form in which it can be dissolved is called digestion. Starch is digested by being changed into sugar.

Malt extract contains a great deal of diastase. It is prepared from germinating barley, and is much used for mixing with the starchy food of persons of weak digestion.

Not only starch, but also many other foods present in seeds require to be changed before they can be used as material for growth. For each kind of food there is a special digestive substance, which is formed when the food is required for use, and so changes it that it can be dissolved in the sap and distributed.

Next we must consider how the plant obtains its food after all the seed-food has been consumed. When all the seed-food has been used, the plant is compelled to prepare for itself all the food it requires. This important duty of food manufacture is carried out by the leaves. The food is made from materials obtained from two sources, the soil and the air.

From the soil, a plant absorbs water and certain substances called mineral salts, which are dissolved in soil water. The soil water, with its dissolved salts, is taken up by the roots, and makes its way up the roots

through fine pipes, then up the stem, and lastly out to the leaves along the leaf-stalks. The branching strands called veins (Fig. 8), which can be seen easily when a leaf is held up to the light, contain a large number of fine tubes, so that by means of the network of veins every particle of the leaf is supplied with soil-water.

FIG. 8.—The lower surface of a leaf showing the branching "veins." The portion of leaf-skin marked by the dot enclosed by the small circle is shown magnified in Fig. 9.

FIG. 9.—Much magnified appearance of the portion of leaf-skin marked by the small dot in Fig. 8. Five of the mouths through which air enters and leaves the leaf are shown.

The rest of the material which the leaf requires for making food is obtained from the air. The air comes into the leaf through tiny holes in its skin. These holes (Fig. 9) are usually most numerous in the skin of the lower side of the leaf.

Now in ordinary air there is a small proportion of a gas called carbon dioxide, and it is this portion of the air which the leaf requires for food-making. In the interior of the leaf, part of this gas is somehow joined

up with a part of the soil-water to make sugar, starch and various other foods.

The formation of foods in the leaves of plants is a very mysterious process which is not fully understood. Nevertheless, it is certain that the power of doing this important work is obtained from sunshine, for in the dark it stops entirely. It is also known that the green colour of leaves is of use for selecting from sunshine certain kinds of light which are specially powerful for this purpose.

The food made in the leaves is passed along the leaf-veins to the stalk and down into the stem, whence it is distributed to all parts where food is required.

It should be clear from what has been read that when a plant has obtained a good hold on the soil—so that its roots can take up as much soil water as is necessary—and has also spread out its green leaves to the light and air, it is able to make its own food. It is to give the young plant time to make these preparations for independent life that its parent packs in the seed a sufficient store of food to keep it alive until germination is complete.

LESSON III

BREATHING AND REPRODUCTION OF PLANTS

LIVING things, whether plants or animals, require food not only when they are growing, but even after they have reached their full size. The reason for this is,

that they are always burning away, though the burning is of a peculiar kind. They require food for somewhat the same reason that a fire requires coal—without it, the fire would get low or go out.

But a regular supply of fuel is not the only thing necessary to keep a fire burning at a constant rate. It must also have a regular supply of air. Fires, animals, and ordinary plants, are all alike in their need for air. Chemists tell us, indeed, that burning is in reality a joining together of fuel with a certain part of the air called oxygen; and it seems that in the life of animals and most plants there is always a joining together of the living substance with oxygen obtained from the air. We ourselves, and all animals, breathe in order to obtain this necessary oxygen to keep the fires of life burning steadily. A plant, too, requires to breathe air for the same reason.

A very important part of coal is called carbon; it is this which makes the coal black. Carbon is also present in the flesh of animals; this becomes black, showing the carbon or charcoal, when it is heated so much as to be scorched. And any part of a plant, similarly, can, by heating it strongly, be shown to contain carbon or charcoal.

Whenever coal burns, and so long as the life of any animal or plant continues, this carbon, and other things as well, are uniting with oxygen.

In each of these cases there is produced a gas called carbon dioxide, which, we have already learnt, is present in the air to a small extent. It flies up the chimney from every fire, it escapes from our lungs when we breathe, and it is given off continuously from various

parts of plants. The breathing of plants is evidently something very similar to the breathing of human beings and animals, all of which breathe by taking in oxygen and giving out carbon dioxide.

Although a plant is alive, it is, as we all know, very much less active than an animal of the same size, and, as might have been expected from this fact, a plant breathes very slowly indeed as compared with an animal.

Also, we must remember that the carbon dioxide given off by the breathing of an animal or a human being is of no use whatever to the animal or to the human being; while, on the other hand, carbon dioxide is an important source of food to a plant.

The curious result is that in the daytime the little carbon dioxide, which is produced during the activity of any leaf, is not given off from it, but is immediately used by that leaf to make food in the manner described in the last lesson. The small amount of carbon dioxide obtained in this way is, however, only about one-tenth of the quantity required for the plant's food; the rest is taken from the air.

It will be useful now to make a list of the similarities we have found between a plant and a human being. We have found that they can both move by their own power; that both increase in size by means of food which they obtain from outside; that even after they have reached full size they require food to replace the loss of their substance which is continually going on; and that both breathe by taking in oxygen and giving out carbon dioxide.

There is another resemblance, which in many respects

is the most wonderful of all. They both have the power of reproduction; that is, of increasing in numbers by offspring.

It is instructive to consider how such a plant as a willow tree reproduces itself and makes more young

Fig. 10.—"Golden palms," or stamen-catkins, on a male willow tree.

willows. From what we have read in the earlier part of this book, we shall expect each new willow to grow from a seed, but we shall wish to know how the seeds are made.

In the spring when the buds have burst it becomes plain that some willow trees are quite different from the others, for on the twigs of some are now to be

seen the rounded objects, golden yellow in colour, which country children call golden palms. On other willow trees the "palms" are soft and silky, and of silvery appearance. The trees on which the golden palms have grown may be called male or father willows: the others are female or mother willows.

FIG. 11.—"Silver palms," or pistil-catkins, on a female willow tree.

Each of the silver palms is made up of a large number of bottle-shaped objects called pistils (*p*, Fig. 12), because each resembles in shape the pestle used for pounding hard substances to a powder in a mortar, and it is in these that the seeds grow and ripen on the mother willows during the early summer. Quite early in the spring the pistils contain tiny grains, but these are

not seeds, although they become seeds later. The help of the male willows is required before the grains can change into seeds, and the help is given in a way which will be explained next.

The golden palms, which grow on the male willows, get their name from the bright yellow colour of certain little knobs which may be seen at the ends of thin thread-like stalks on the palms. Each knob with its stalk is called a stamen. Fig. 12 shows a pair of stamens on the left.

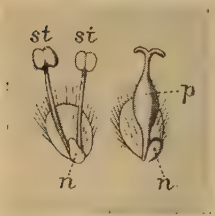


FIG. 12.—Willow flowers (magnified). On the left, a male flower. On the right, a female flower. *n*, nectary; *p*, pistil; *st*, stamen.

Inside the knob of each stamen there is some yellow dust called pollen, and when the knobs burst open in spring the pollen dust can easily be brushed off by anything touching the palms. It is this pollen from the male willows which is needed to make the seeds grow on the female willows. The male trees and the female trees often grow at some considerable distance apart, and, of course, they cannot go to each other. How is the pollen to be carried from the males to the females?

The pictures on this page show that at the bottom of each pistil, and at the bottom of each pair of stamens, there is a little swelling (*n*) called a nectary. The nectary makes a sweet fluid called nectar, very similar to honey, of which bees are very fond.

Now, although a great many flowers make sweet fluid of this kind, very few of them are open so early in the year, and the bees are therefore quite glad to go to both

male and female willows for nectar. They go to the golden palms for the sake of pollen too, which they find a very nutritious food.

When a bee is busy searching for nectar and gathering pollen on the golden palms, it is sure to get its hairy body dusted with pollen, and if it comes a little later to the silver palms for more nectar, it can scarcely prevent some of this pollen from getting on the ends of the pistils. Off the bee flies on its busy search for food, little thinking how useful it has been to the tree; and the pollen dust it has left behind soon makes the grains in the pistils change into seeds.

In this way both the male and female trees take a share in forming the seeds, and, as we know, the seeds in due course may grow up to form a new generation of willows.

In almost all flowers either stamens or pistils or both are to be found easily, and in all cases their work is to make seeds which can become new plants. Every such plant, therefore, may be said to have had both a father and a mother, just as truly as every human being has had both a father and a mother.

LESSON IV

PLANT AND HUMAN PHYSIOLOGY COMPARED

THE foregoing lessons have shown that there are many striking resemblances in the conditions of the life of a human being and of an ordinary plant. Many of

their powers have been shown to be very similar, too; they can both move of themselves; they can both feed on material obtained from outside, in order, at first, to grow to their full size, and afterwards to avoid wasting away; they both breathe by taking in oxygen and giving out carbon dioxide; they are both able to become parents and so produce new living things like themselves.

But when we come to study closely the ways in which these powers are exercised, we find some rather striking differences. Of these, one of the most important is in the method of obtaining food. It was mentioned in the first lesson that we and all animals obtain our food from plants, for even our flesh-food comes from animals which have lived on grass or other plant-food themselves.

An ordinary green plant, on the contrary, is quite independent of all other forms of life. It makes its own food from the water and mineral matter which it takes from the soil, and the carbon dioxide gas which it obtains from the air. It could not do this except by the help of a green dye in its leaves and certain other parts; and such plants as mushrooms and moulds, which have none of the green dye, are to a certain extent compelled, like animals, to rely on other living things for their food.

Nevertheless, in studying plants, people are impressed far more by their resemblances to human beings and animals than by the differences between them. It will be instructive to consider a few more of these resemblances.

Any part of a living thing which performs a special

duty is called an organ, and its duty is called the organ's function. Thus the eye is the organ of sight, or the same fact may be expressed by saying that sight is the function of the eye. In a plant the chief

FIG. 13.—A microscope in use.

function of a leaf is the preparation of food; the function of a flower is reproduction, and so on. We might draw up quite a long list of the organs and their respective functions both in plant and man, and we should then realise more clearly that the plant, as well as the man, is of very complicated structure.

We may usefully think of such a living thing as a building in which many kinds of work are being done.

To be suitable for the various kinds of work, the parts of the building—the organs—are naturally of different sizes and shapes. Yet when we look at them closely we find that they are all built of somewhat similar materials. The stones or bricks of which the complicated building is composed correspond to tiny living particles called the cells of animals or plants.

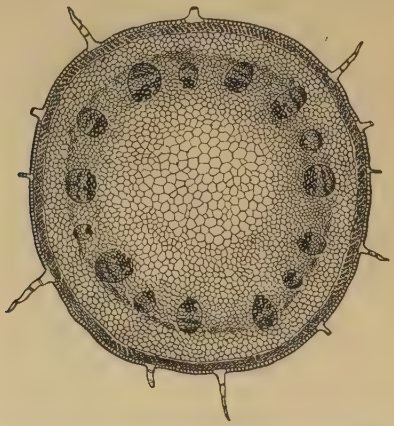


FIG. 14.—Thin slice across a young stem, as seen with a microscope. It shows that the stem is made up of many different kinds of cells and tissues.

Such cells cannot be examined except by the help of a microscope (Fig. 13), because they are so very small. They are of various shapes, in the different organs, as the stones or bricks of a building are of various shapes, but each is a little piece of living jelly, taking its share in the work of the organ. A group of cells of the same kind, and doing similar work, is called a tissue.

Since each organ is composed of tissues, which in

their turn consist of tiny living cells all taking their share in the work of the organ, it follows that the activities of the animal or plant can be carried out satisfactorily, only so long as the cells themselves are able to perform their duties properly. We can put this into other words by saying that the whole animal or plant remains healthy only so long as the cells themselves are healthy, but that it becomes diseased if the cells are unhealthy.

It seems strange at first to think of a man's body as made up of countless millions of little living things labouring together for the good of the whole; one group doing one kind of work, another group doing another kind, and all controlled by the cells of the brain and the rest of what is called the nervous system.

Nevertheless this way of thinking of the body is quite right, and it has given clever men ideas which have helped them to understand why some things keep the whole body healthy, and others injure it. It is possible to watch similar little living cells through the microscope and to notice how their appearance changes when they are treated in different ways.

Also, because the cells of plants are so similar in many ways to the cells of animals and human beings, much useful knowledge has been gained by noticing the effect which various drugs have upon plants. A great deal of interesting study of this kind has been carried out during the past few years.

It is, for example, well to know what is the exact effect which alcohol has upon living plant-cells. It has been found that very minute doses indeed of this

substance make the cells more active for a little time, but this effect does not last long; on the contrary, the cells quickly become less active than at first, and indeed are killed altogether unless the alcohol is extremely weak.

Very small amounts of chloroform or ether similarly increase the activity of certain plant-cells for a time, but these drugs act as distinct poisons when used in larger quantities. Plants which are under the influence of small quantities of these and other poisons have been shown to have less power of resisting the attacks of disease germs.

These facts and others mentioned in earlier lessons—which show how, in so many respects, plants resemble human beings—are interesting enough in themselves. We are, however, concerned with them in this book chiefly because they throw so much light on the activities of the human body. It is when we understand how entirely correct was Lord Herbert of Cherbury in calling plants our fellow-creatures, that we are in a position to turn our knowledge of them to the greatest advantage. Plants have long been studied as the source of all our food; they furnish timber, fuel, clothing materials, many medicines and other useful substances; their beauty has given great delight to mankind. They are now studied also that we may learn from them how to keep the good health with which most of us are endowed at birth, but which in too many cases is lost by ignorance and carelessness.

LESSON V

THE GENERAL ARRANGEMENT OF HUMAN BONES

WHAT is called the skeleton of the fully grown human body consists chiefly of bone and partly of gristle or cartilage. These hard parts are of use in three principal ways. First, some of them protect the delicate softer organs. Excellent examples of this use of the skeleton are to be found in the flat bones of the brain case; in the bony tube—the spinal column or backbone—which encloses the spinal cord; and in the bony cage (formed by the breast-bone, the ribs and the adjoining bones of the spinal column) which protects the heart and lungs.

A second use of bones is to stiffen certain parts either so that they can be made to move with more precision, or in order to support the weight of other parts. We immediately think of the bones of our limbs as examples of this use.

The third use of the skeleton is to form a jointed framework of hard parts capable of being pulled into new positions by means of muscles. It is this arrangement which enables us both to move from place to place and to use our limbs with so much freedom in other ways as well.

It adds greatly to the interest of the study of the skeleton to try, in the case of every bone we examine, to make out which of these duties it fulfils. Most of the bones will be found to take a share in at least two of these kinds of work.

We find, for example, that the bones of the head—

collectively called the skull—not only protect the brain and the organs of smell, sight and hearing, but they also have to do with certain movements. The lower jaw is jointed to the side of the brain case and can be moved on a sort of hinge both up and down, and also from side to side and forwards and backwards, so as to make the biting and chewing movements which are so necessary when we eat.

Further, two knobs at the base of the skull work in hollows in the first bone (called the atlas vertebra) of the spine, so that the head can rock forwards and backwards when it is pulled by muscles of the neck. And the atlas vertebra is so jointed with the second vertebra (called the axis) that it can, with the skull, be turned from side to side by other muscles of the neck.

The rest of the backbone or spinal column is no less interesting. Its bones, called vertebrae, are really bony rings, each very thick in front, thinner (but nevertheless quite strong) at the sides of the spinal cord which they surround and protect, and forming a sort of spike at the back. There are also other projecting pieces at the sides.

Between the thick front parts of each vertebra and the next are elastic pads, which act like the buffers between railway coaches. These lessen the shock very greatly when a person sits down suddenly, and at all times they make the vertebral column more springy.

The vertebrae are not, except in certain places, rigidly fastened together, but each is able to slide a little on those above and below it. The result is that from the skull to the hip region there are as many

bending places as there are vertebrae, and the column is able to bend forwards, backwards, and from side to side as it is pulled by the muscles which are attached to its vertebrae. Naturally, since the column is a sort of supporting pole for the body, this bending of the spinal column explains the ease with which we can turn our bodies into so many different positions.

The vertebral or spinal column evidently shows very well two of the great uses of the skeleton. We shall next see that it helps to illustrate the third also.

At their back ends the twelve pairs of ribs are attached by movable joints to the twelve vertebrae of the chest region. At their front ends all but the lowest two pairs of ribs are connected with the breast-bone. When the chest is expanded in the act of breathing-in, the ribs—and the breast-bone with them—swing upwards, each turning a little, as if on a hinge, on the end attached to the backbone.

It is in the bones of the limbs, however, that the best examples are found of the action of the skeleton in pulling parts of the body into new positions. The long bone of the upper arm has a knobbed end which, at the shoulder joint, works in a cup-shaped hollow or socket, at one corner of the flat, triangular shoulder-blade. This kind of joint is called a ball-and-socket joint. It allows movement to take place in all directions.

Close to the shoulder joint, the shoulder-blade is firmly connected to a curved rod called the collar-bone, the other end of which is movably attached to the upper end of the breast-bone.

The nature of the shoulder joint and the action of

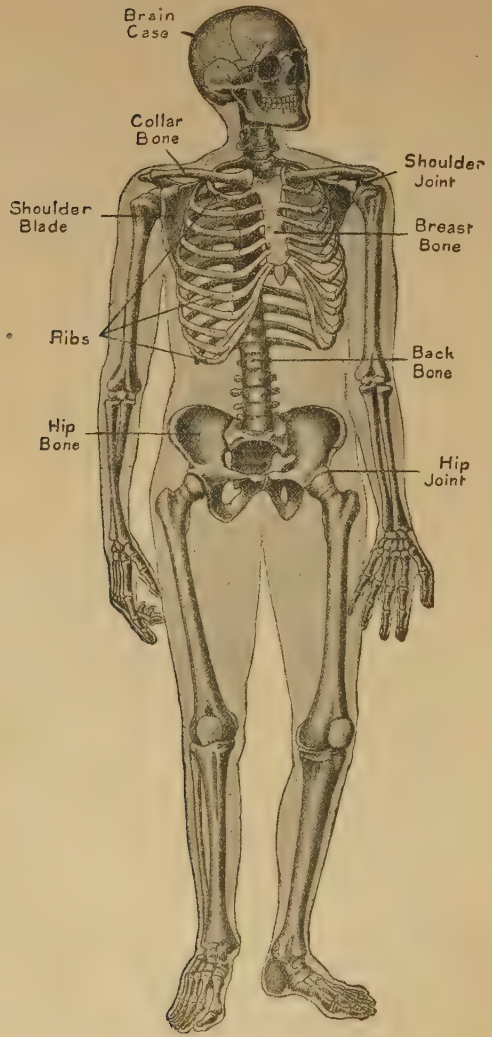


FIG. 15.—The human skeleton.

muscles on the upper-arm bone, the shoulder-blade or the collar-bone, make it possible to move the upper part of the arm in any desired direction.

At the elbow joint, the bone of the upper arm is in contact with two bones which reach from the elbow to the wrist; one on the thumb side and one on the little finger side. The latter of these forms a very perfect hinge-joint with the upper-arm bone. It is this joint which is used when the biceps muscle pulls up the lower arm; that is, when the arm bends at the elbow.

The other bone of the forearm, which reaches from the elbow to the thumb side of the wrist, can move separately; and as its lower end supports the wrist bones, and these in their turn are joined to the hand, the movements of this long bone have a very important effect on the position of the hand. The two bones between elbow and wrist lie side by side when the hand is palm upwards, but the one on the thumb side crosses over the other when it is necessary to turn the hand over to lie palm downwards. The movements of the bone, as the hand is turned over, can be felt easily at the wrist.

The wrist bones are small; they are eight in number, and allow this part of the limb to be moved with great freedom. Following the wrist bones come five bones in the palm of the hand leading to the thumb and fingers. The bone leading to the thumb alone can move separately. In the thumb are two bones, and in each finger three.

The bones of the legs are very much like those of the arms in arrangement, but as the legs carry all the

weight of the body they differ in many interesting respects from the arms. Some of the most important differences are those between the hip region and the shoulder region. In the first place the hip bones (unlike the shoulder-blades) are rigidly attached to the spinal column, and cannot be moved separately. The vertebrae of this part of the spine have, moreover, grown together to form one firm mass incapable of bending, and the two hip bones themselves are joined together in front.

Secondly, the hip bones are so shaped that with the adjoining part of the spine they form a basin which not only protects, but also supports the weight of, important organs of the abdomen. And, in the next place, the socket of each hip joint is much deeper than that of the shoulder joint, so that although the thigh bone cannot move quite so freely as the upper-arm bone, it is not nearly so liable to slip out of position or become dislocated.

The knee is different from the elbow in various ways. One difference is, that at the front of the knee joint there is a rounded bone called the knee-cap, which slides up or down in a smooth groove when the knee is straightened or bent. There is nothing of the kind at the elbow.

There are two bones side by side between knee and ankle, corresponding to the two between elbow and wrist, but we cannot use them so freely, and we are unable to turn over our feet as we can turn over our hands.

The principal difference between the foot and the hand is in the arrangement of the bones of the foot to

bear the weight of the body. For this purpose they form an arch—called the arch of the instep—which acts precisely as the arch of a bridge or the beams of a roof in distributing the weight safely.

There are other differences between the upper and lower limbs which any one can find out for himself, and nearly all these differences can be explained by the differences in the duties of the arms and legs. Nevertheless, most people will be struck by the resemblances rather than by the differences between them.

LESSON VI

THE BONES AND THEIR GROWTH

UNDERSTANDING the general arrangement of the bones in the human body we shall next wish to know more about the nature of a bone, and how it grows and keeps healthy. Clear ideas on these points can be formed most easily by the examination of a fresh bone obtained from the butcher. For this purpose, what the butcher calls a marrow bone is best.

Such a bone is called a marrow bone because except at the ends it is hollow, the tubular cavity being filled by a red fatty material called marrow. The bony material surrounding the marrow is very dense and hard. At the ends, the bone does not contain any hollow space, but is of a rather spongy nature.

The outside of the bone is covered by a kind of skin containing many blood-vessels, which nourish

it, while the cells of this skin cause the bone to grow in thickness.

Covering the spongy end of such a bone where it forms a joint with another bone, is a layer of smooth, shining gristle or cartilage (Fig. 16), which in life is kept constantly wet by a lubricating fluid, so that the

FIG. 16.—The upper end of the thigh bone in its socket in the hip bone, which is sawn through to show the nature of the joint.

friction between the two bones of the joint is very slight indeed. This smooth cartilage of the joint is very clearly seen at the "knuckle end" of a fresh marrow bone.

All the rod-shaped bones of a fully grown person's limbs are very much like this. The hard tubular

shaft of the middle part is very strong and yet not too heavy. Indeed, engineers regularly use tubes in place of solid rods whenever they wish a machine to be strong and at the same time light, as in the frame of a bicycle. Further, the strands of bony material in the spongy tissue at the ends of the bone are arranged so as to give the greatest strength possible in the circumstances.

Fig. 17.—Thigh bone sawn through lengthwise.

In all such bones of persons who have not reached their full growth, there is a layer of cartilage near each end, stretching across between the spongy tissue and the tubular shaft; and it is in these places that new material is laid down to make the bone grow in length. When the bone has reached its full size, these plates of cartilage are themselves replaced by bone, and the growth of the bone in length ceases.

There is a danger that by jerking the limbs of young children, a careless person may tear these layers of cartilage and so prevent the limbs from growing properly afterwards.

The other bones of the body, which are not rod-shaped, have no hollow marrow cavities, but the outer layers are hard and dense while the inside is of a more spongy nature. For this reason the structure of the flat bones of the skull is sometimes compared to that of a slice of toast.

In the early stages of growth of the human body, bone is absent, its place being taken by cartilage. As a person grows older, more and more cartilage is replaced by bone, but in even a fully grown man or woman there is some cartilage remaining in the skeleton.

This is why the skeleton of a child is so much softer than that of an adult. Being softer, it is more easily bent into a wrong shape which may remain permanently. The cramping of the toes into tight boots and shoes in infancy is often responsible for much discomfort in later life; encouraging babies to walk before their legs are strong enough to bear the weight of the body may cause them to have permanently crooked legs, or may result in injury to the arch of the instep; and a habit of standing or sitting in a cramped or unnatural position in childhood may give a lasting awkwardness of figure or even produce bad curvature of the spine.

In young children the bones of the brain-case do not fit together so closely as they do later, because room must be left for growth of the bones at their edges in order that the brain may increase in size. One place in the head, where a gap remains between the bones until the age of about eighteen months, is well known to all who have to take care of babies. At this place there is special danger that the brain may be injured by an accidental blow on the head or by a fall, and the wise nurse bears this constantly in mind.

It is interesting to make a few simple experiments on bones. One may be laid on a hot fire, being held if necessary by an old shovel or an old spoon, and it

will be seen that the bone blackens and bursts into flame. It does not burn completely away, however, but when the flame has gone out and all sign of burning has disappeared, there is left a white substance having the shape of the original bone, but easily crumbling into powder. This consists of what is called the mineral matter of the bone. If a pinch of it is put into strong vinegar, it dissolves, as a pinch of salt would dissolve in water.

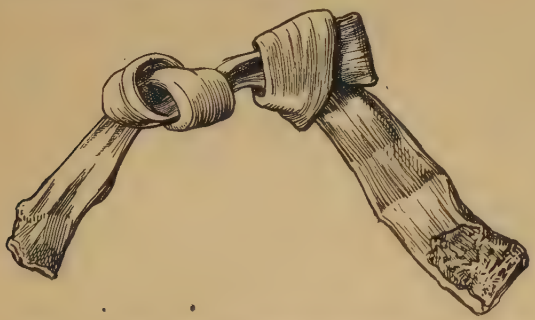


FIG. 18.—A human rib tied in knots after removal of the mineral matter by acid.

A fresh bone—say a rabbit bone—may be soaked in strong vinegar for several days to dissolve out the mineral matter, and in this case there is left the material which would have burnt away if the bone had been put in the fire. This is called the animal matter of the bone. It can be taken out of the vinegar, washed in water, and examined. It is soft like india-rubber and may be bent in any direction, or even tied in a knot, without breaking.

It is easily understood, by any one who makes these simple experiments, that the more mineral matter a

bone contains, the harder and the more brittle the bone becomes, and the more likely it is to be snapped across by any accident. The proportion of mineral matter in the bones of the living body increases with age, and this is the reason why the bones of elderly persons are more likely to be broken by a fall, than those of young people.

LESSON VII

THE MUSCLES

THE muscles which pull bones into new positions form what is known as the lean meat of animals, and if we wish to learn more of their nature, we cannot do better than examine the lean of such a piece of meat as a leg or shoulder of mutton, or the flesh on the limbs of a rabbit.

The lean is seen to consist of masses of reddish flesh, thick in the middle but tapering to each end. Such a mass is called a muscle; it is composed of a number of bundles of flesh lying side by side. The muscle is surrounded by a thin but tough and shining skin, called connective tissue, which also passes between the smaller bundles; at each end of the muscle the connective tissue forms a strong cord, called a tendon, which is fastened to a bone. There is generally a ridge, or at least a roughness, on the bone at the point where a tendon is attached.

Muscles have a very remarkable power of becoming

shorter and thicker when they receive messages through certain nerves from the brain or spinal cord. This change of shape is known as the contraction of the muscle. It is plain that when a muscle contracts, its ends—and also the bones to which its ends are fastened by the tendons—must be pulled closer to each other.

FIG. 19.—A muscle, showing a tendon at each end.

Commonly, one of the bones is more or less fixed, while the other is pulled into a new position when the muscle contracts. This action is shown very clearly when a limb is bent, as when the arm is bent at the elbow. In this case the muscle which contracts to cause the motion is the well-known biceps muscle, in the front of the upper arm. The fixed bone is the shoulder-blade, and the upper end of the biceps is fastened to it by tendons. The movable bone to which the lower end of the biceps is attached, is one of the two bones of the forearm. When, therefore, the biceps contracts, the forearm is drawn upwards, the motion taking place on the hinged elbow joint.

When the arm is straightened again, the forearm is pulled downwards by the contraction of another muscle at the back; this is the triceps muscle. Its lower end can be felt easily at the elbow when the arm is held very straight—in other words, when the triceps is fully contracted.

Evidently the biceps and triceps muscles produce opposite effects when they contract. One muscle is

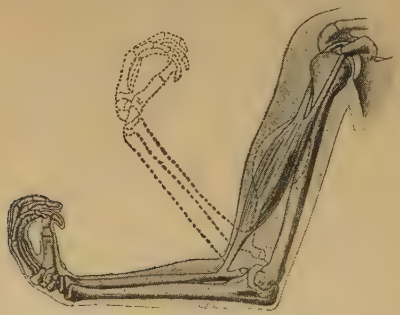


FIG. 20.—The action of the biceps muscle in bending the arm at the elbow.

stretched more or less whenever the other contracts, and it is by balancing, as it were, the action of one against that of the other that we are able to make

FIG. 21.—The biceps and triceps muscles.

this movement of bending the arm with so much accuracy. We can bend it to the utmost extent or

slightly, as we wish, and we are always able to alter the amount of the bending by contracting one muscle or the other a little more.

A similar state of things is to be found in the other movements of the limbs, as well as in those of the head and trunk: every movement can be balanced or reversed by the action of an opposing muscle or set of muscles.

The picture on this page shows the action of the muscles which keep the body erect when standing. The muscles marked I. and II. would pull the legs backwards, by bending them at the ankle and knee joints, if their action were not balanced by the forward pull of those marked 1 and 2. Similarly the muscles marked III. pull the trunk backwards, while those marked 3 pull it forwards.

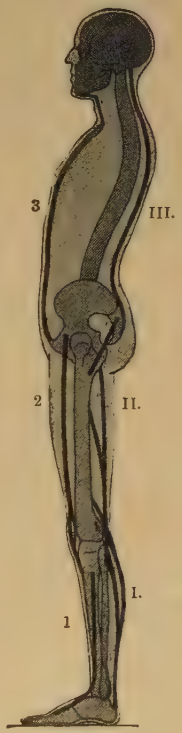


FIG. 22.—How the body is kept erect when standing.

So long as the brain is healthy and alert, the messages sent along the nerves control the contraction of these opposing sets of muscles so that they obey our wishes exactly. Each pulls with the exact force required to bring about the position we wish to adopt.

The muscles which are thus under the control of the will are called the voluntary muscles. It is clear that their perfect action depends upon two

things—on their own health and strength, and on the orders which are sent to them from the brain.

A muscle is made larger and stronger by regular exercise, by being regularly supplied by the blood with good food and oxygen, and by being kept clean by the prompt removal of the poisonous waste matters which the body makes.

While regular exercise is necessary for every one, it is not in general wise to try to produce very powerful muscles capable of lifting great weights. For men whose work requires great bodily strength this may be desirable, but for most people it is better to train all the muscles to act promptly and accurately rather than to cultivate a few at the expense of the rest.

Such prompt and accurate behaviour of the muscles depends largely, as we have seen, upon the character of the messages which the brain sends to them through the nerves. Even a powerful muscle may act imperfectly by pulling too hard or not enough, or not at the right moment, if it receives foolish orders. Such poisons as alcohol, and the injurious drugs present in tobacco, strong tea, etc., if they get into the blood, interfere considerably with the precision of muscular action, because they prevent the brain from knowing exactly what movements are required and what the muscles are doing.

There are some muscles which are not under the control of the will; these are called involuntary muscles. They are concerned with the beating of the heart, and the movements made by the walls of the digestive tube, blood-vessels, and other internal organs, to the action of which the brain cannot pay

direct attention. They are not fastened to bones, and do not as a rule produce movements which are visible on the outside of the body. They will be referred to again in a later lesson.

The involuntary as well as the voluntary muscles are controlled by messages sent along nerves, and their useful action, also, is interfered with if poisons are present in the blood.

LESSON VIII

THE CLASSES OF FOODS

WHENEVER a muscle contracts it becomes slightly smaller, because part of it is destroyed to give the muscle the power to contract. The destruction of muscular tissue which takes place is very similar to the destruction of any fuel which goes on when that fuel is burnt; heat is produced, and in addition energy (that is, the power of doing work) is furnished, and may be used to drive a machine. In a similar manner the doing of any kind of work by the living body is made possible only by the destruction of a part of the active organ—heat being produced at the same time.

Evidently this loss of tissue must be made good very soon, or the organ would dwindle in size and become unable to perform its duties properly. Food is taken into the body to make good the loss of tissue. Food is also necessary to provide material for the growth in size which goes on during infancy, childhood

and youth. We may, indeed, say that a food is anything which can be used by the body to build up tissue.

Now the tissues of the body differ a great deal in character, and require building up by different kinds of food. Thus, a man who does a great deal of muscular labour will need food somewhat different from that of a man whose work is chiefly intellectual, because the food of the first man will be required to repair his muscles to a greater extent and to repair his brain to a less extent than that of the second. Still, every one needs, in his food, materials capable of building and repairing all his organs, although it is wise to modify the food according to the special kind of life one leads.

All the living tissues of the body are composed of certain very simple materials which chemists call elements, although the elements are combined together in a manner which is not at all simple. Of these elements one is always carbon—commonly called charcoal—as is proved whenever any piece of meat is so overcooked as to be charred. The black carbon can then be seen.

A second element present in all living tissues is nitrogen ; this cannot be shown so easily, because when nitrogen occurs alone it is a colourless gas. Four-fifths of ordinary air is nitrogen, however, so that it is quite a common element. Two other important elements of all living tissues are oxygen and hydrogen; these also are very common, since pure water is made up entirely of oxygen and hydrogen. Indeed, a great part of every tissue is water—although both oxygen and hydrogen are present also in what is left

when all the water has been removed. There are other elements present as well, but in smaller quantities; sulphur and phosphorus are the chief of these. We need not consider them further at present.

Finally, when any tissue is strongly heated for a long time in the air, so that all the animal matter is burnt away, there remains a certain amount of ash or mineral matter. In bone—which, of course, is a tissue—this mineral matter forms a considerable part of the whole, as has been explained in Lesson VI., and a smaller amount is present in all other parts of the body.

We are now in a position to understand why every person's food must contain carbon, nitrogen, oxygen and hydrogen, as well as certain mineral substances. It would be a great mistake, however, to think that anything containing these elements could be used as food. A lump of charcoal, though really carbon, can not give the tissues the carbon they require. Three and a half pounds of marble contain as much carbon as there is in a pound of sugar, but whereas sugar is a valuable carbon food, marble is quite useless as a food. Similarly, there is a great deal of nitrogen in saltpetre, but no human being or animal could use this nitrogen for making good the waste of his tissues.

From these facts we see how very different are such substances as marble and saltpetre—which have no food value whatever—from the ordinary materials which form our meals. The former are known as inorganic, the latter as organic substances. Almost all the food of an animal except water must be organic in character and be derived directly or indirectly from

plants; while, as we have seen, a green plant is able to manufacture its food entirely from inorganic materials.

The organic substances which furnish our foods can be grouped in three classes. The first class of food-stuffs consists of what are called the proteids. White of egg, or albumin, is a good example of a proteid. It contains nitrogen, carbon, oxygen and hydrogen, all combined in a form which the body can use easily for building and repairing its tissues. Another well-known proteid is the curdy matter present in milk. It is called casein, and it forms a great part of cheese. In lean meat there is a great deal of a proteid called myosin, and in wheat-flour there is another proteid called gluten. All these proteids—as well as others which need not concern us at present—are alike in containing nitrogen, as well as carbon, oxygen and hydrogen, united in such a way as to allow of their being used for repairing tissue.

It is a remarkable fact that proteids are the only foods from which our bodies can take and use nitrogen; and this is the reason why nothing else can take their place in our meals. We must supply nitrogen to our tissues, or we shall die. In other words, we must eat proteids or we shall die, however much we eat of other foods.

The second class of food-stuffs includes the fats and oils of animal or vegetable origin. The fat of different kinds of meat (perhaps as margarine) and of fish, the cream of milk—perhaps in the form of butter, the oils which occur in the kernels of various nuts and in other seeds, all belong to this class. They contain no nitrogen, but consist entirely of carbon, hydrogen

and oxygen. They are chiefly useful as a supply of carbon, and are eaten with proteids, which do not contain enough carbon to form a suitable food alone. Fats are most valuable to people living in cold countries; for they enable the body to keep warm better than any other kind of food. They have also been found to help other foods to repair the tissues of our bodies.

The third class of food consists of starch and the different kinds of sugar. The foods in this class also consist of carbon, hydrogen and oxygen, but these elements are not combined in the same proportions as in fats, so the class of the sugars and starch is given a different name. Such foods are called carbohydrates. Like fats they are eaten with proteids in order to make up the amount of carbon required, and their action in the body helps the muscles a great deal at times of extra strain. Armies on the march are sometimes given extra sugar to enable them to perform any unusual amount of muscular work.

Pure water also is a true food, since much water is being given off regularly from all our tissues and needs to be replaced. The elements present in water are oxygen and hydrogen, and these add themselves to the oxygen and hydrogen which are also contained in the proteids, fats, and carbohydrates eaten during meals.

Finally, we must remember the great amount of mineral matter present in bones, and we can understand one reason why some such material ought to be included in our food. There is another reason, however, not so easy to understand, but even more important. This is, that without a certain amount of these salts or mineral

matters, our bodies would be quite unable to make use of the other foods. They are, therefore, as necessary as proteids themselves. Almost all the mineral matter we require is present naturally in ordinary foods, and certain green vegetables contain specially large amounts.

LESSON IX

TYPICAL FOODS

It will be interesting to learn next which of our common foods contain the proteids, fats, carbohydrates and mineral matters described in the last lesson. When we know this we shall understand why these foods are so useful to us, and why certain foods are eaten together at meals.

The commonest of all foods in this country is bread made from wheat-flour. About half of the weight of a loaf consists of carbohydrates, made up almost entirely of starch. About two-fifths of the bread is water. Perhaps one-twelfth of very good bread is composed of proteids, and there is also a little fat and a little mineral matter. The drawing on page 49 shows this in a form which is easily understood.

It is clear that all the classes of food are present in ordinary bread, and when we remember too that well-made bread is pleasant to eat, easily digested, and cheap, we are not surprised that people think so highly of it.

At the same time it must be admitted that the proportions of proteids and carbohydrates in bread are not quite what are required. There is so little proteid that a man who ate enough bread to get all the proteid he needed would eat with it far more carbohydrate material than would have sufficed to supply him with the necessary carbon.

Evidently it is well to eat with bread some food which contains a larger proportion of proteid. The diagram on page 49 shows that lean meat contains a much greater proportion of proteid than bread does. There is also more or less fat present in all meat, but there are no carbohydrates, either starch or sugar.

A man living on lean meat alone would find in it all the kinds of food necessary, but the proportions would in this case also be unsuitable. This time, however, there would be too little carbon present; so that if a man ate enough lean meat to give him all the carbon he required, he would at the same time consume so much proteid that his health would probably suffer.

With bread as the only food, therefore, a man would eat too much carbon. With meat as the only food he would eat too much nitrogen. We begin to see that it would be much wiser for the man to eat bread and meat together. It would be possible, by combining these two kinds of food to make a meal, to get just enough carbon together with just enough nitrogen.

Of course, people had found out by experience long before the composition of ordinary foods was fully understood, that it was much pleasanter, as well as much better for the health, to eat different kinds of

food together at one meal, and we now understand partly the reason for this.

Fish is very like meat; indeed, the difference between the two lies chiefly in the flavour, and the useful diagram on page 49 shows that many foods can replace meat as the chief source of the proteid required in a meal. Eggs also are seen to have a very similar composition.

There are no carbohydrates present in meat, fish and eggs. Fats and carbohydrates seem to serve the same purpose in the body when they are once digested, and we might at first be inclined to suppose that the fat in these foods would do instead of carbohydrate to make up the carbon required. Most people, however, would find it disagreeable to be deprived of starchy foods and compelled to replace the starch by fat.

There is no food which contains all the necessary materials in such suitable proportions as milk. Proteids, fats, carbohydrates and mineral matter are all present, and in forms which serve for all the needs of a complete meal. The large amount of natural water in milk is somewhat of a drawback to its use as the entire food of grown-up people; also the amount of proteid is a little greater than is necessary. This is why milk is so often made into puddings with starchy foods. Milk is often eaten in the form of "junket," which is made by adding rennet to warm milk. Junket readily separates into curds and a watery liquid called whey.

One of many reasons why milk is so excellent a food for babies is that sugar and not starch is the

carbohydrate present. Young babies cannot digest starch; but the peculiar kind of sugar in milk, together with the curdy proteid and the fat of the

FIG. 23.—Diagram to show the relative proportions of proteids, carbohydrates and fats in common foods. The water and mineral matter are not represented.

cream, provides them with the exact materials they require.

Cheese is made by curdling milk with rennet and afterwards pressing the curd. The cheese or curd contains the proteid and the fat, but nearly all the sugar of the milk remains behind in the watery whey. For this reason the amount of proteid is too great, and the amount of other food classes too small, to make cheese suitable as an entire food; eaten with bread, its deficiency in carbon is made good.

Meat, fish, eggs, milk and cheese are animal foods. Animal foods are rich in proteids and fats, but contain very little carbohydrate material. Vegetable foods on the other hand contain a large amount of carbohydrates, but are deficient in proteids and fats. It is easy to understand, therefore, why most of our meals consist of combinations of animal and vegetable foods. Each supplies what the other lacks.

We shall do well to compare carefully the composition of potatoes, oats and rice with that of wheat bread. It will then be clear that each of these could be made to replace the others, but that they could not, without injury to health, form the only food.

There is one kind of vegetable food, however, which is even more interesting. The seeds of beans, peas, lentils and similar plants contain a quite unusual amount of proteid matter, so that it might be supposed these foods (called pulses) could take the place of animal food. Indeed, many people find that they can live comfortably and healthily without meat or fish if they eat peas, beans or lentils instead.

There are others, however, who cannot easily digest

these seeds except quite occasionally, and such persons are wise to eat meat or fish even if for other reasons they would like to be vegetarians.

Fruit, and such vegetables as lettuce, cabbage, cauliflower, carrots, turnips, spinach, asparagus, onions, and the like, are useful not so much for their food value as because they contain substances which help to keep the blood pure. Indeed, if people were to eat such things more freely they would need less medicine.

LESSON X

THE SELECTION AND PREPARATION OF FOOD

HAVING learnt what kinds of food are most useful and why, we ought to know how to choose these things, so that we may be sure we are getting them of good quality.

It is fortunate that unwholesome meat and fish are, as a rule, easily distinguished from the sound and good food. Meat should be rejected if it has an unpleasant smell. It should be firm to the touch, and should not become wet when kept in a cool place. The lean of beef and mutton ought to be red, not pink or dark purple, and the fat ought to be white or pale yellow. Good veal is pink; it is unwholesome when bluish in colour. If pork shows greyish-white spots, it should not be used for food. Sausages are unsafe, unless the maker can be relied upon to use only sound meat for their manufacture.

Fish which has a strong disagreeable odour, and feels sticky to the touch, is not fresh, and should not be eaten. Unsound fish is a particularly dangerous article of food since it often contains deadly poisons called ptomaines. These are more speedily formed in some fish—as in mackerel, especially—than in others; and mackerel should not be eaten unless it is known to have been caught quite recently. Sometimes, but less frequently, ptomaines occur in meat also.

Eggs which are unsound are easily recognised when the shell is broken, and the odour is fortunately very disgusting. When an egg is broken carefully into a basin the yolk usually bursts if decomposition is setting in.

Milk so readily becomes unsafe for food, unless everyone handling it is very careful to keep it free from dust and dirt of any kind, that special precautions are necessary with it. If there is any fear whatever that it has been exposed to dust or kept in dirty vessels, it should be heated at once to just below the boiling point and kept hot for five minutes. This treatment kills any disease germs which may be present in it. Any vegetables and fruit which show signs of decay should be removed from the main supply or this will be spoiled as well.

It is no less important to know how food should be stored before it is used. Many people know that food "goes bad" because little living things, called microbes, get to it. Most commonly the microbes reach the food in the dust which is always present in air. They are also carried in many cases by flies. We shall learn more of this subject in Lesson XIII., but what has

just been said will make our first rule clear:—Keep food covered, so that the flies and dust cannot get to it.

Many people have an idea that the air ought to be allowed to get freely to milk and other foods. This would be quite right if the air in our houses were pure; for pure air alone would do the food no harm. The fact is, however, that anything exposed to the air is also exposed to dust in nearly all cases, and the microbes in dust make food "go bad." It follows that if one room in particular in a house ought to be kept scrupulously clean, it is the room in which food is stored. If eggs are washed quite clean and wiped dry after being taken from the nest, they will keep good for a much longer time than if they are put aside while dirty. Indeed, they may thus be kept sweet for more than a year—although the egg gradually dries up within the shell in time.

The second rule is that food should be kept as cool as possible. The reason is that microbes increase most rapidly in warm places. We know how fishmongers rely upon ice to keep fish from decaying. Similarly, milk will remain fresh for a much longer period if kept very cool.

No better example could be given of the remarkable effect of great cold on food than the fact that meat is regularly brought to England from New Zealand and other very distant countries, in ice-cold chambers, and arrives quite sound and suitable for eating.

The use of heat for killing microbes in milk has been pointed out already. It is on the same principle that meat, fish, tomatoes, etc., are often sealed up whilst very hot in tins, and can then be kept for a

great length of time without spoiling. Such tinned materials are quite wholesome if the food used was good, and the sealing was done properly; but food ought never to be allowed to stay in the tins after they have been opened.

Microbes cannot multiply in dry surroundings. This fact explains why many fruits such as apples, prunes, apricots, grapes (raisins), and currants, which have been dried carefully and packed, may be kept for a great length of time without taking any harm. They merely need washing and soaking in water to be ready for use again.

A few of our foods are commonly eaten raw; various fresh fruits, and certain green vegetables, which are used in the form of a salad, are examples. In this case it is sufficient to wash the food very carefully before using it, rejecting all that shows signs of decay, or of being under-ripe.

Among civilised nations, however, all meats and most vegetable foods are cooked before being eaten. There are various reasons for cooking food. The most important is that thorough cooking destroys all the microbes and other living things which may be present in it.

Another object of cooking is to make the food more easily digested. In the case of meats, the cooking softens the connective tissue and allows the fibres of the meat to come apart easily. With vegetable foods, the action of cooking is to burst open the tough cells in which starch and other useful materials are contained, and to cause the starch grains themselves to swell and soften.

Some vegetables which are important foods in the tropics are poisonous when raw, but are made quite safe and wholesome by cooking.

Lastly, by cooking, foods are made more enjoyable because of the new flavours which are produced. In many cases, also, the appearance is altered and rendered more attractive.

Roasting, boiling and stewing are the commonest methods of cooking. These processes will be understood better if we remember the changes which are brought about in an egg when it is heated. The albumin, or what we call the "white" of a raw egg, is an almost colourless liquid, which may be dissolved in water. When the egg is cooked, however, the albumin becomes stiff and solid, and cannot be dissolved in water.

The lean of meat contains a proteid very similar to the albumin of eggs; and this food also will dissolve somewhat readily in cold water; but when it is heated it is stiffened and becomes unable to dissolve in water.

It is easy to understand, therefore, that if a rich broth or soup is required, the best way to cook the meat is to put it in cold water and heat it gradually until it boils. During the early stages of cooking the albumin of the outer part of the meat is dissolved in the water. By the time the cooking is finished, the meat has lost a great deal of its flavour, which has been taken up by the broth. The meat still contains nearly as much nutriment as at first, however, because only the albumin of the outer portions could be dissolved by the water before the rest was made stiff.

In stewing, the meat is cut into small pieces before the cooking is begun.

If the object of the boiling is to obtain juicy and well-flavoured meat, the piece should be plunged at once into boiling water. This stiffens the albumin on the outside of the meat, and forms a sort of crust which protects the inside from the water. Similarly, in roasting, most of the juices are kept inside the meat by the crust of stiffened albumin which forms on the outside.

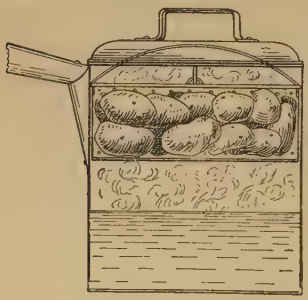


Fig. 24.—A double saucepan, for cooking foods by steaming.

In the preparation of peas, beans or lentils, which many people eat as a substitute for meat, it is important to use soft water, and to give plenty of time for the cooking.

The vegetables which have been referred to as useful for the medicinal substances they contain should be cooked so that the juices may be saved. A double pan, or a "steamer" (Fig. 24), is best for this purpose.

LESSON XI

THE DIGESTION OF FOOD

When food is eaten it is taken into a tube called the alimentary canal. This consists of the mouth,

the gullet, the stomach and the intestines. The wall of the intestines is very similar to the skin which covers a sausage.

By the time the food has reached the end of the intestines it has lost all the useful material which was in it, and nothing is left but waste rubbish, which—unless it is got rid of daily—forms poisons which may injure the health.

Where has the useful part of the food gone? It has soaked through the wall of the alimentary canal into the blood, which is always flowing through fine tubes in this wall. These fine tubes are joined to other blood-vessels which carry the food to the tissues requiring it.

Knowing this, we understand how it is that such organs as the brain and, say, the muscles of the limbs—which are at some distance from the alimentary canal—are able to get the food which is their necessary building material. The food is carried to them by the blood.

Evidently we must next learn how the food we eat is able to get out of the alimentary canal and into the blood, for it certainly seems strange that such food as a piece of lean meat should be able to pass through something resembling the skin of a sausage.

Most people thinking about this problem would understand that all the food must, by some means, be made soluble in water before it can pass into the blood. This is quite true, and, as we know, a great deal of our food is not soluble in water when we eat it, though a small part of it, such as sugar, is soluble. It is clear that one change which must go on in the

alimentary canal is the change of insoluble food into soluble material.

But this is not all that is necessary, for there are some foods which, even after they have dissolved in water, cannot soak through such a membrane as the skin of a sausage.

The albumin or "white" of a raw egg might, for example, be placed in a sausage skin and not one drop would soak through. Because the white of raw egg cannot soak or diffuse through such a membrane, it is said to be indiffusible, although it is soluble. Cooked albumin is both insoluble and indiffusible. Cooked starch is slightly soluble, but it is indiffusible. Sugar, on the other hand, is both soluble and diffusible.

We may say, then, that during the passage of food along the alimentary canal it must be made soluble and diffusible, in order that it may be able to pass into the blood, for it cannot do any good to the body until it gets into the blood. The change of food into a soluble and diffusible form is called the process of digestion.

Digestion begins in the mouth; in this first part of the alimentary canal, the food is mixed with a fluid called saliva, which has the power in all people, except young babies, of changing starch into sugar. It is, therefore, very important that the food should be kept in the mouth until it has had time to be mixed thoroughly with the saliva.

Very complete chewing or mastication of the food is necessary to ensure this, and the food ought not to be swallowed until it has been ground by the teeth to a smooth pulp. Even soft food such as porridge and

puddings ought to be kept in the mouth for several seconds, so that the saliva may have time to mix with and act on the starch present.

The saliva of babies under the age of about six months is not able to change starch into sugar, and for this reason such babies ought not to be given starchy foods. To them starch would not only be useless, but would interfere with the digestion of other foods.

Saliva is a fluid made in certain organs called salivary glands, which have the position shown in Fig. 25. Each gland has a little pipe called a duct, through which the saliva flows into the mouth.

FIG. 25.—The alimentary canal.

In the action of swallowing, the food is passed along the gullet to a bag called the stomach, which has thick and muscular walls. In the stomach it is the turn of the proteids to be digested. In this case the digestive juice is not the saliva, but a fluid called gastric juice, which is made in small glands like very fine tubes in the wall of the stomach. A great part of the thickness of the stomach-wall consists

of muscles, of the kind which we learnt in Lesson VII. to call involuntary muscles. These muscles cause the stomach to move in such a manner that the food inside is stirred up thoroughly and mixed with the gastric juice. In this way most of the proteid matter is gradually made soluble and diffusible.

After the food has been in the stomach for some hours it passes into a narrower part of the alimentary canal called the small intestine. This is about twenty feet long, but it is so coiled that it does not take up so much room in the body as might have been expected.

Immediately the food enters the small intestine, two more digestive fluids are poured upon it. One of these is called bile; it is made by a very large gland called the liver; and its special duty is the digestion of fat. At this stage in its passage along the alimentary canal the fat of the food has become very much like cream, and the bile digests it more easily on that account.

Poured into the food at the same time as the bile, is a digestive fluid called pancreatic juice, a liquid made by the pancreas—the organ which, in some animals, is called the sweetbread. This fluid is, in many ways, the most important of all the digestive juices, for it can digest starch as saliva can; it can digest fats as bile can; and after it has mixed with a liquid made by the intestines themselves, it can digest proteids as gastric juice can. Thus, if the other juices have left any useful food undigested, the pancreatic juice completes their work.

Before the food has reached the other end of the

small intestine, a large part of the useful food—digested in this manner—has soaked through the wall; so that much of what passes on to the next portion of the alimentary canal is waste.

This next portion of the canal is called the large intestine. Its course is shown in Fig. 25. Here a great deal of water, together with any digested food which may remain, passes from the alimentary canal into the blood. Finally, what is left—now not only useless but becoming dangerous to health—is discharged from the body.

LESSON XII

THE ABSORPTION AND USES OF FOOD

THE passage of digested food from the alimentary canal into the blood takes place chiefly in the small intestine. The proteids have been turned into a soluble and diffusible form: starch has been changed into sugar, which is soluble and diffusible; and the useful mineral matters of the food are also ready to pass into the blood.

These digested foods, therefore, ooze out of the alimentary canal into the blood, and are carried away by the current of the blood. Now, it is an important fact that the blood circulating in the wall of the alimentary canal does not flow straight on to the heart. It is carried first to the liver, and this organ selects certain parts of the food which is in the blood,

and stores them up for a time until they are required by the body.

It is as if a workman who had just received his week's wages were to call at the bank on his way home, and put in the bank the money he did not require immediately. In this case the workman is the blood, and the wages are the food it has absorbed. The bank is the liver, at which we may say the blood calls on its way home to the heart. From the heart, of course, the blood, with the remainder of its contained food, is distributed to all parts of the body.

It is chiefly the sugar—much of it formed by the digestion of starch—which is kept back by the liver, to be used later when the body is hungry or doing hard muscular work. But if the body is not allowed to become hungry, and does not exercise its muscles much, the same material is stored up in the body as extra fat. This is why well-fed people, who do not take enough exercise, become too stout. It also explains why people who seem likely to grow stout ought to eat less starchy food and sugar, as well as to take more exercise.

So far, the absorption of the fatty part of the food has not been described. Curiously enough, the digested fat is not absorbed directly into the blood, but passes first into very small tubes called lacteals, which lie alongside the blood-vessels in the wall of the intestine.

The lacteals open into larger tubes, which join together and at last discharge their contents into a vein at the root of the neck. Thus, the fat reaches the blood at last, as the other foods do, but it takes a

roundabout path, and so differs from the other foods in not passing through the liver on its way to the heart.

If we consider again the various reasons why food is necessary to us, we shall now be able to understand why the quantity and the kind of food must vary according to the age, activity, and manner of life of the person eating it.

The first use of food is to supply the material necessary for the growth of the tissues. The second is to supply the material necessary to repair the tissues; for, as we know, neither the heat of the body nor the activity of any organ can be kept up without some loss of tissue.

It is plain that while children require food for both the growth and the repair of tissues, a fully grown person needs it merely for the second purpose: to make good the daily loss of tissue. Also, healthy children are more active in proportion to their weight than adults.

For the mere growth of tissue, proteids are the principal foods required; although, as we have learnt, proteids alone do not form a satisfactory diet.

Starch and sugar are especially useful to persons who do much muscular work or exercise, because they seem able to supply the muscles with the chief materials lost during muscular activity. Extra sugar in the food has been found to prevent people from becoming tired so readily by hard muscular work.

Fats could probably repair wasted muscle in the same way as sugar and starch if they were more easily taken up by the body. As it is, most people find it easiest to digest fatty foods in cold weather; and fat is

indeed specially useful for keeping up the supply of bodily heat.

We see from these facts that more starch and sugar ought to be included in the food of such a man as a navvy, who is doing hard muscular work, than in that of such a man as a clerk, who lives what is called a sedentary life. In cold weather and countries a

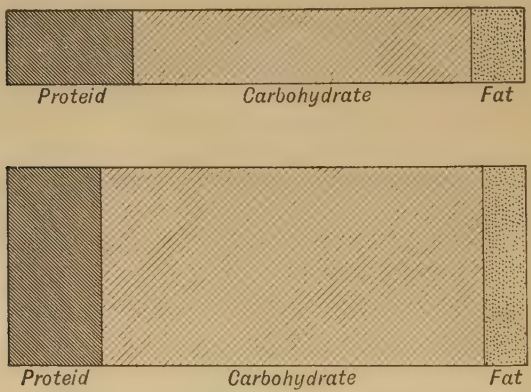


FIG. 26.—Comparison of the amount and composition of the food required by a child of five (upper figure) and a full-grown man (lower figure). Water and mineral matter are not represented.

greater amount of fat may be used with advantage to replace the usual starch and sugar.

It is also clear that at all times children need more food in proportion to their weight than is required by adults. Thus, an average child of five has a weight of about two-sevenths that of a full-grown man, but it requires much more than two-sevenths the amount of food (Fig. 26).

Also, because such a child is growing rapidly it

needs a greater proportion of proteid food than if it were full grown, as proteids are so necessary for growth. Indeed, while proteids need not amount to quite one-fifth of the total food of an average man, nearly one-fourth of the food of a child of five ought to consist of proteids (Fig. 26).

Children also need a greater proportion of mineral matter—chiefly for the growth of the bones and teeth—than is necessary in the food of adults. Such foods as milk, milk puddings, oatmeal, eggs, etc., contain these useful materials in a form which children can make use of, and form the best foundation for healthy growth.

The active habits of children no doubt explain why young people are so fond of sugar. Pure sugar, and sweets made from it, are quite wholesome when eaten in moderation and with meals, but many kinds of cheap sweets contain substances which are bad for the health.

At all ages it is of great importance to cultivate habits of regularity in eating. Meals should be taken, if possible, at the same time every day, and as a general rule, nothing ought to be eaten between meals.

It is best not to drink much during a meal, but afterwards. If this rule is observed we are more likely to masticate the food thoroughly and mix it properly with the saliva. It is not easy to swallow food which has not been well mixed with liquid, and the liquid used for this purpose ought to be the saliva.

Many people eat more than is necessary, especially when the food is particularly pleasant to the taste. This is foolish, because it causes discomfort afterwards.

If overeating is practised as a regular habit the whole system is injured permanently; and the greedy person is despised by all sensible people.

Finally, it must be remembered that in all foods there is some waste material which cannot be digested, and that this has begun to become offensive and poisonous by the time when it reaches the end of the intestine. It is of the highest importance that it should be expelled from the body at daily intervals, and regular habits in this respect are quite necessary if health is to be maintained.

LESSON XIII

FOODS TO BE AVOIDED

It will be well in this lesson to consider a number of foods against which people should be warned. First on the list comes a number of poisonous plants which are dangerous because they look so much like useful foods.

We have learnt the great value of peas, beans, and lentils. It is important to know that the very similar seeds of laburnum are poisonous. A great many children are said to have died from eating these seeds, thinking that because they look so much like peas or small beans they must be wholesome. It is said that people who have eaten the seeds of the bitter vetch have sometimes lost the use of their legs in consequence.

The potato and tomato are highly valued for the good food they yield, but it is dangerous to eat green potatoes and the leaves of the plant. Also many plants related to these bear poisonous but attractive-looking berries. People ought to know that there is a risk in eating the fruit or any other part of an unknown plant. The water dropwort, a common plant in this country, is very like the carrot in many ways, but is poisonous; and unfortunately the poisonous root of monkshood resembles the root of horse-radish.

There is a danger, also, that certain poisonous toadstools may be mistaken for mushrooms. Only persons who understand the differences between the wholesome and poisonous kinds ought to gather mushrooms for food.

Among the foods which may be described as risky are certain "shell fish"; mussels especially should be eaten with great caution, if at all, as they seem particularly liable to produce poisonous substances called ptomaines.

Children ought to be warned of the risk there is in eating the ice-creams sold in the streets by hawkers. In many cases such ice-creams are made in dirty places or by dirty people, and sometimes contain either ptomaines or the germs of disease.

When food of any kind decays, decomposes, or, as people say, "goes bad," the change is caused by extremely small living things called microbes, bacteria, or germs. These organisms cannot be seen except by the help of a powerful microscope, but they occur in all dust and dirt. When they reach any moist food, especially if the place is warm, they multiply with

great rapidity and set up changes which cause poisonous substances to be produced.

Fortunately the same changes generally give rise to disagreeable odours, so that the sense of smell is especially useful in letting us know that decayed food is not fit for use. Even persons who have not a keen sense of smell, however, can often see by the different appearance of the food that decomposition has begun, in stale vegetables and over-ripe or decayed fruit which may not at first have a very bad odour. Decomposed food of any kind ought never to be eaten: it is certain to injure the health, and it may cause serious illness or death.

The preservation of food by drying, freezing, sealing from the air whilst hot, and by other methods has been referred to. Other good ways of keeping food wholesome are preserving in sugar or salt, according to circumstances. We are thus able to enjoy such things as jam and salted fish or meat at times when the fresh foods are not available. All these methods act either by killing the bacteria or by preventing them from growing and multiplying, and in each case the food remains good.

It has been found out that certain substances—such as boracic acid and salicylic acid—have also the power of stopping the action of bacteria, and such substances are often used as preservatives. These things are injurious to the health if they are present in any but very small quantities, and many doctors think that even the small amounts added to foods are harmful, especially to babies.

Cream containing boracic acid is quite often sold

in pots, and similar preservatives often occur in potted shrimps, potted meats, sausages, and confectionery. Such foods ought to be eaten only when freshly prepared; then preservatives are unnecessary.

The greatest objection to the use of these preservatives is, however, that they remove the warning, objectionable odour from foods which have begun to decay already, without removing the poisons which have been caused by decomposition. In this way unscrupulous dealers have been able to make use even of rotting fish, or meat, and give it an appearance of freshness when it was laden with filth and deadly poisons.

Poisonous substances are sometimes added even to sound food with the object of making it more attractive. Bottled peas have sometimes been found to contain poisonous arsenic and copper compounds, put in to make the peas greener. Cheap sweets, and the icing on cheap cakes, are sometimes coloured with poisonous substances.

In the case, however, of most adulterated foods—that is, foods which are not of the quality which the purchaser has a right to expect—the object of the dishonest dealer is to make an increased profit by mixing the food with something which is of lower value, though it may not be directly injurious. Thus, sometimes, water is added to milk and other foods; or some of the natural cream of milk is removed; gelatin is added to cream; margarine is added to butter; paraffin is added to margarine and lard.

Food adulteration is usually detected by certain chemists known as public analysts, who are supplied

by inspectors with samples of the suspected foods for this purpose. Anyone who has reason to suppose that any food is adulterated may have it tested for a smaller fee than usual by the public analyst of his district.

Lastly, we ought to remember that there are many foods which are quite sound but nevertheless ought not, as a rule, to be eaten except in small quantities and by people of very good digestion. Such foods are pastry, pickles, and strong condiments. These foods often either interfere with the action of the digestive juices or are in themselves difficult to digest, so that they throw unnecessary work on the system.

LESSON XIV

WATER

A PLENTIFUL supply of good water is quite as necessary as a plentiful supply of good food. Indeed, it has been pointed out that water is itself a food in the sense that it plays a part in the building and repair of tissue. This fact is understood more clearly when it is known that about seven-tenths of the whole body consists of water.

While most of the water in the body is contained in the muscles and other tissues, about one-tenth of it is constantly flowing, as blood, along the pipes called blood-vessels, which are carrying material from one part of the body to the other.

The importance of the share which water takes in the work of the body may be judged by the fact that every day between four and five pints of water are given off, in one form or another, by the body of an average grown-up person. It is evident that about this amount must also be taken in, either drunk as beverages or eaten with the food; for only a small part of the four or five pints can be provided in any other way. A person could live longer without food than without water.

It is only recently that people have realised how much the health of human beings depends upon the abundance and quality of their water supply. It is now known that a great many epidemics of disease have been due to the presence of certain bacteria in the water which was drunk.

The greatest care is consequently taken by all sensible persons to prevent drinking water from being contaminated by the droppings of animals or by sewage matter. The reason for these precautions is that when disease germs have occurred in water they have been traced repeatedly to animal or human refuse of this kind.

Formerly there was an idea that all water which was clear, bright and free from smell was fit to drink, while muddy water of any kind was supposed to be injurious. It is now known that clear water may be extremely injurious because contamination with the germs of disease may cause no change whatever in its appearance, or may, indeed, even make it look bright and sparkling.

On the other hand, although the best drinking

water is clear, water may be cloudy at times from the presence of a little harmless peaty matter or clean sand or clay. We see from these facts that the appearance of water really tells us very little about its fitness for drinking purposes.

If a Pasteur-Chamberland filter, such as those shown in Fig. 27, can be obtained, it will be found

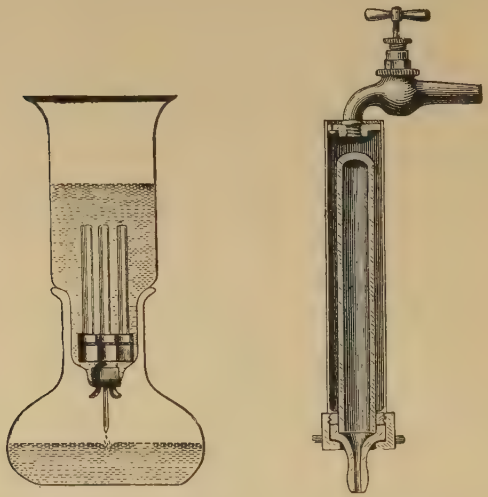


FIG. 27.—Pasteur-Chamberland filters. The one on the left is a table-filter; that on the right is attached to a water tap.

useful for removing the occasional cloudiness of water. Ordinary charcoal filters are worse than useless, and may make fairly good, but cloudy, water quite unfit to drink, even although it is rendered clear.

If there is any reason whatever to suspect that animal droppings or sewage are getting into the water supply, the water may be made safe by

boiling and cooling it before drinking. The flat or insipid taste produced by the boiling may be removed by pouring the water backwards and forwards several times from one vessel to another, so as to mix it with air again.

Although only specially trained scientific men can say with certainty whether water of doubtful quality is fit for drinking purposes, anyone by making a few simple experiments can get an idea of some of the most important differences between good and bad waters.

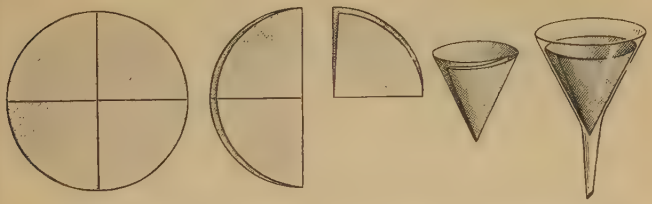


FIG. 28.—Method of folding a circular sheet of blotting paper to form a filter.

A glass of water taken from a river is seen to be more or less muddy from the presence of solid particles. If the water is allowed to stand, these particles fall to the bottom—the largest first and the smaller particles later. Generally, when the water has stood for a long time it is found that all the solid particles in it have settled to the bottom, leaving the liquid above quite clear.

Such grains of solid matter—whatever be their size—are spoken of as suspended matter. They are said to be held in suspension by the water. Suspended solid matter can be removed most easily by filtering

the water. On a large scale, water is filtered by letting it flow through beds of sand.

FIG. 29.—Method of filtering through blotting paper in a funnel.

Anyone making these experiments, however, will probably find it easiest to filter the water through blotting paper held in a glass funnel, in the manner shown in Figs. 28 and 29. The suspended matter remains on the blotting paper, while the clear liquid flows through.

A quantity of such clear filtered water may be taken and heated next in a porcelain dish over a Bunsen burner or a spirit lamp. Long before the liquid boils, bubbles of air will be seen to form on the inside of the dish, grow larger, and at last rise to the surface and burst. It is easy to see the difference between such air bubbles and the bubbles of steam which escape when the water boils. The air which is thus proved to be dissolved in ordinary water gives it a refreshing taste which is absent from freshly boiled water.

FIG. 30.—Water boiling in a porcelain dish.

After the water has boiled for some time it may

be poured into a glass vessel and held up to the light. Sometimes it will be found to contain fine suspended matter at this stage, even though it was quite clear when the heating was begun; this is especially the case with water which has flowed over chalk or limestone rocks. This suspended matter is really chalk: water containing dissolved air can also dissolve chalk or limestone, but when the air is expelled by heat the chalk also separates.

Water containing much dissolved chalk brings about a great waste of soap in washing, and also it is considered to be unsuitable as drinking water for persons suffering from certain diseases. The harm done by the presence of chalk in water, however, is of very little consequence compared with that which may result from the presence of animal or human refuse.

Water which is badly contaminated by such refuse often has an unpleasant odour when heated, though it may be quite without smell when it is cold.

If the heating of the water in the dish be continued, the liquid will presently boil completely away. The moment the dish is dry it should be examined. In nearly all cases a dull layer will now be found on the porcelain. This is the solid matter which was in solution, or dissolved, in the clear filtered water.

It is instructive to continue the heating of this residue—as it is called—of solid matter and see whether it chars or turns black. If it does, there must have been some organic matter in the water. This may have been either a little harmless vegetable matter, or, on the other hand, it may have come from sewage pollution. If filtered water yields a residue which turns black

on being heated it ought, if possible, to be tested by an analytical chemist. In the meantime it ought not to be drunk before it has been boiled.

Although the best drinking water contains something besides water—if only dissolved air—it is usual to call water pure if it contains nothing which can injure the health of those drinking it. In this case "pure" means "clean."

This use of the word pure is not applied to milk and other foods, however. These are called pure only if they contain nothing else whatever. Milk to which even good drinking water has been added is not pure but adulterated, although it may be still quite wholesome.

LESSON XV

THE SOURCES OF DRINKING WATER

All the water in the sea, in rivers, lakes, springs, and wells has at some time fallen from the clouds in the form of rain or snow.

When air containing invisible moisture—generally called water vapour—is sufficiently cooled, the moisture is condensed: that is to say, it forms drops of liquid water. Such drops of water, produced in this way in the sky, are at first very small indeed, like dust; and they may remain in this form for some time, giving the appearance which we know as a cloud.

Often, however, the tiny particles of water-dust in

the cloud join together and become drops which are too heavy to remain in the air. These then fall as a shower of rain. When the air is very cold, snow and snow-flakes are formed from it instead of the water-dust which produces rain-drops.

Of course snow and ice are merely solid water,

Fig. 31.—Water evaporated from sea or other water surfaces forms clouds, which are condensed as rain, that eventually reaches the sea through rivers.

which can be turned into a liquid again by warmth. And the liquid water turns gradually into water vapour—or, as we say, dries up—when it is exposed to the air. It is changed into vapour more quickly when it is heated. When a liquid changes into a vapour it is said to evaporate.

When we remember the thousands of square miles of water which are freely exposed to the air, and the

constant evaporation which is taking place, we are not surprised that there is always a large amount of water vapour in the air, ready to be turned into liquid water again by cooling.

At the moment of its formation, rain is pure water; there is nothing whatever in it but water. But as it falls through the air it dissolves the gases of the air, and in towns it takes up some of the smoke and other impurities in the air. Nevertheless these things are not usually very injurious, and freshly caught rain-water is quite wholesome to drink, especially after filtering through a good filter, such as is shown in the picture on page 72. If rain-water is used regularly for drinking purposes, it ought to be stored in a clean and covered tank.

Rain-water is the most economical to use for washing, because a very small quantity of soap produces a good lather. For this reason rain-water is said to be very soft. Lead service pipes should be avoided with very soft waters.

When the rain reaches the ground some of it flows over the surface and may reach a stream. It naturally dissolves more or less of the soil or rock over which it flows, so that from this time forward its suitability for drinking or washing depends largely on the kind of land over which it flows.

When the water flows over such hard rocks as granite, it will take up very little material and probably remain very "pure." When it flows over ground on which are the droppings of many animals it will be contaminated by them and may give rise to disease in persons who drink it. When it flows to a great extent

over limestone rocks, it will—with the help of the gases it has taken up from the air—dissolve some of the limestone and become more or less "hard"; and a great deal of soap may be required with it to make a good lather in washing.

FIG. 32.—Thirlmere. The water of the lake is carried through pipes to supply Manchester, 80 miles away.

In many cases the water is obtained directly from rivers to supply the towns on their banks. Advantage is also taken of the lakes which occur along the course of many rivers, and the lake water is sometimes carried along pipes to towns at great distances (Fig. 32). Where many small streams collect the rain-water of the "gathering ground," it is the custom

to construct artificial lakes, called reservoirs, for the same purpose.

Of the rain falling on the earth only a part flows directly into streams and rivers. A great deal sinks at once into the ground, especially if the rocks at the surface are sandy or composed of some other porous

FIG. 33.—Section showing porous rocks overlying impervious rocks, and the resulting formation of a simple spring.

material. Such water often sinks quite deeply into the ground before it is stopped by a rock—a layer of stiff clay, for example—which will not let water pass through it. Rocks of this kind are said to be impervious.

Having reached an impervious rock the water flows over it, much as it would flow over an impervious rock at the surface of the ground, but of course much more slowly, until at last it may find its way to the surface and gush forth as a spring. Springs formed in this manner are naturally at a lower level than the

place where the water originally sank into the ground, perhaps miles away.

Coming often from great depths in the earth, the water of springs is often noted for its purity. Obviously, it has been protected from the contamination of animal or human refuse. In its passage through the rocks, however, the water sometimes dissolves large quantities of substances which are not common where the spring reaches the surface. In certain cases the water of such "mineral springs," as they are called, has a high medicinal value. The springs of Bath and Harrogate are well-known examples.

Springs, like rivers, do not always furnish a regular supply of water, and for that reason wells are usually constructed to store spring water, as reservoirs are constructed to store river water. The greatest care is necessary not to allow stables, pigsties, or anything from which animal or human refuse might drain, to be placed near a well. Special precautions must be taken when the ground near the well is porous.

Some of the rain which falls is immediately evaporated again, but all the rest takes a part in dissolving material from the rocks of the earth and washing this dissolved material, together with suspended matter, into the sea. Here, too, evaporation is constantly going on; water is being always changed into vapour, to begin the same work again, but the dissolved materials are left behind in the sea. Owing to the accumulation of these dissolved materials the sea contains a very large quantity of matter in solution, and it is this which gives sea water its "salt" taste.

LESSON XVI

BEVERAGES

In Lesson XIV. we learnt the great importance of water to the human body. When the supply of water is running short we become aware of the need for more by a feeling of thirst, which is satisfied by the drinking of some water. The water quickly passes from the alimentary canal into the blood, and is soon carried to all tissues needing it.

Water only can really quench thirst, and all beverages are made almost entirely of water. Yet many of our beverages are more enjoyable, or useful, because they contain other substances besides the water.

Some of the beverages we drink contain not only water but food as well, and when we are both hungry and thirsty such beverages are particularly welcome. Milk is the best example of a substance which is "both food and drink."

We have learnt already that milk contains all the classes of food-stuffs in forms which are readily digested and absorbed, and, indeed, that the large amount of water naturally present in milk is the chief reason why grown-up persons do not find it suitable as an entire food. It is clear that as a combined food and beverage milk is most valuable.

Skim-milk, as we know, differs from new or "whole" milk in having been deprived of a large part of its fat in the form of cream. The skim-milk still contains

the original proteid, sugar, and mineral matters, and is excellent as a nourishing drink.

Butter-milk is in many respects similar to skim-milk, but a change has taken place which gives butter-milk a distinct flavour, which many people find very refreshing. Also, in butter-milk there are often large numbers of certain bacteria which are believed to help the body to keep healthy. For several reasons, then, butter-milk is a very useful beverage to persons who can digest it.

Properly made, barley-water is a nutritious and refreshing drink. It is prepared by putting washed barley in a saucepan with cold water and boiling for about three-quarters of an hour. After straining and cooling, the liquid is ready for use. Besides having a distinct food value of its own, barley-water increases the digestibility of milk with which it is mixed. Another useful cereal drink is made by stirring up a little oatmeal in ordinary cold water.

Cocoa is greatly valued by many people as a nourishing beverage. Its food value is not so high as it is often supposed to be, though it contains all the classes of foods, namely, proteids, fats, and starch. Prepared with hot milk and sugar, as it often is, cocoa is, of course, very rich in food material. It also contains something which, like certain substances in tea and coffee, makes people drinking it feel more lively and cheerful.

Cocoa is made from the seeds of a small tree growing chiefly in the forests of Central and South America. It has been cultivated for a very long time, and was worshipped by the ancient inhabitants of Mexico.

Cocoa was first brought to Europe by Christopher Columbus.

Photo. Underwood & Underwood

Fig. 84.—Gathering Cocoa Pods near Port Limon, Costa Rica.

In the manufacture of cocoa, the seeds are carefully dried and roasted, and their husks are removed. Most of the oil is then extracted and the seeds are ground to

form the powder known as cocoa. The extraction of the oil makes the cocoa more easily digested.

Chocolate is also manufactured from the seeds of the cocoa tree. In this case the oil is not generally removed, but the seeds are crushed or ground to form an oily paste, and sugar and other materials are added. The pasty chocolate is then allowed to harden in moulds.

Scraped chocolate is often made into a breakfast beverage by stirring it into hot milk and water and adding sugar. An ounce of chocolate to half a pint of water and half a pint of milk gives about the right proportions. Such a drink is naturally very nutritious for persons who do not find it too rich for digestion.

Perhaps the simplest of the nourishing drinks is water sweetened with sugar. Water alone has really a certain food value, as we have already learnt, and its usefulness is much increased by the presence of a little sugar.

The preparation of nutritious beverages for invalids is described in Lesson XL.

It would be a mistake to suppose that nourishing beverages are always more useful than water alone. If the alimentary canal contains plenty of food, the thirst should be quenched by water alone, or by one of the non-nourishing beverages which will be described in the next lesson. It is always safe and wise to sip good cold water to quench the thirst. The water should not be drunk quickly, or it may do harm by chilling the stomach.

LESSON XVII

NON-NOURISHING DRINKS

It is plain that when we prepare a beverage by mixing water with something else, we do so because we are not content merely to quench our thirst. We either wish at the same time to obtain some food, or we want the drink to have a more pleasant taste than water has alone; or it may be that we feel not only thirsty, but dull and heavy as well, and we feel the need of something to make us bright and cheerful.

We have already learnt the nature of some of the best food drinks; we must next find out what are the most useful beverages for refreshment when food is not required. It is a curious fact that at such times nearly everyone enjoys a drink containing fruit juice. The taste for fruit drinks is so common because the juice of ripe fruits really is good for the health. Not only does the juice usually contain some sugar, but also there are often present substances with a pleasantly sour or acid taste, and these help to keep the blood pure and to prevent constipation.

What can be more refreshing on a hot day than a tumbler of cold water with which the juice of half a lemon has been mixed? If a teaspoonful of sugar be also added, it will hide much of the sour or acid taste of the lemon juice, though it does not really destroy the acid. This can be done if necessary, however, by adding a little bicarbonate of soda to the lemonade. Immediately the bicarbonate is put in, the liquid will

begin to fizz, owing to the escape of a gas called carbon dioxide, which is formed at once. Many people prefer the taste of the fizzing lemonade to the taste of the

Photo. Underwood & Underwood.

FIG. 35.—Picking lemons, near Palermo.

sweetened sour juice, but of course it is possible to have both, if less of the bicarbonate of soda be used. It may be interesting to notice at this point that sourness and sweetness are evidently not opposite qualities,

because lemonade made in this manner is both sour and sweet at once. The opposite of sweet is bitter.

The best lemons are obtained from Sicily and other countries in the Mediterranean region; but lemons are grown in many other parts of the world having a somewhat similar climate.

The lemon is really a kind of orange in which the juice does not become sweet, even when the fruit is ripe. Lime juice is obtained from another fruit of a very similar nature. It has no connection whatever with the ordinary lime tree.

Orange juice and lime juice are both as good for the health as lemon juice, and may be used in a similar manner for mixing with water to make refreshing beverages.

In preparing home-made lemonade and orangeade, a lemon-squeezer, which can be bought for a penny or so, is very useful, and prevents waste of the juice.

Many of the liquids sold in penny bottles as lemonade and lime juice contain very little, if any, of the genuine juice of the fruit, but are made of water with artificial acids and flavouring which may injure the health. On the other hand, several good firms have recently begun to supply quite wholesome fruit juices in bottles. This is particularly the case with lime juice; and as the lime fruit itself is not commonly met with in this country we cannot easily obtain lime juice in any other form.

The fresh juice of many other fruits may be used in the same manner and with the same good results, even when, as is sometimes the case, the pulp of the fruit itself causes indigestion.

In winter, when fresh fruits are more difficult to obtain, a pleasant and wholesome drink may be made by stirring up a teaspoonful of good jam or marmalade in a glass of water.

Aerated waters owe their attraction to the presence of the same gas, carbon dioxide, which is given off when bicarbonate of soda is added to lemon juice. In this case, however, the gas is forced into the water by special machines at the time of bottling. The escaping gas has a refreshing effect on the mouth and throat when the aerated water is drunk, and it also assists digestion to some extent.

Properly made, soda water contains, besides the gas, a little bicarbonate of soda, and this is particularly useful when indigestion has caused the contents of the stomach to become too sour or acid. The unpleasant feeling known as heartburn is really due to extra sourness or acidity in the stomach.

What is called potash water is very similar to soda water, except that bicarbonate of potash has been added instead of bicarbonate of soda.

Unfortunately, some other aerated or mineral waters, as they are often called, are flavoured by unscrupulous manufacturers with artificial acids, and in many cases are harmful.

What is known as ginger beer is aerated water sweetened and flavoured with ginger. When properly made, it is quite a good and wholesome drink.

LESSON XVIII

TEA AND COFFEE

TEA and coffee are so useful that it is important to know clearly what is the nature of the good they do, and also what are the risks of injury to health when they are used wrongly.

Most grown-up persons have experienced the cheering effects of a cup of tea or coffee at times when the body was tired but not able to take at once the rest which it needed; or at times when for some reason they felt heavy and dull.

The power which tea, or coffee, has of taking away for a time the feeling of fatigue or of hunger has naturally made some thoughtless people suppose that the drinking of tea or coffee is often as good as actual rest or food. This is, of course, a great mistake. When the tissues need food, nothing but food will satisfy that need. When they are clogged by the waste rubbish made during their activity, only rest will allow the rubbish to be cleared away completely.

What tea and coffee can do is to enable the organs of the body to work more briskly for a time. Often this is very useful by helping them to make an extra effort when such an effort is required. Such a beverage might, for example, clear away a slight headache much in the way that a sharp walk might, if the headache was merely due to the sluggish action of some organ which the tea or coffee might make

more lively. In such a case the effect would be really good.

But it ought to be understood that tea and coffee

Photo. Underwood & Underwood.

FIG. 36.—Picking tea in Ceylon.

make the tissues waste away more rapidly, and that instead of taking the place of food and rest they

will make food and rest more necessary than ever in a short time.

Sir Michael Foster, who was a great authority on such subjects, said: "The strengthening, the freshening which comes from a cup of milk is like the greater heat which a fire gives out when you put more coal or wood on it; the strengthening and freshening which comes from a cup of tea is like the greater heat which a fire gives out when you blow it with a bellows or stir it up with the poker."

This makes it quite clear that tea, and coffee too—for coffee acts similarly—will do more harm than good to those who need food; but that it may be of real use in other cases, by making the life-fires of the body burn more briskly when they are getting dull from some other cause than lack of fuel.

It is, however, only when tea is carefully made that it is a useful drink even in such circumstances as these. Boiling water should be poured on the leaves, and the tea allowed to stand for three or four minutes only. The liquid—but not the leaves—should then be poured into a hot tea-pot. It spoils the tea to let the leaves remain in the liquid for longer than about four minutes, because at the end of this time something called tannin, which interferes very much with digestion, is extracted from the leaves.

The useful effects of properly made tea are due to a substance known as theine, which the hot water takes from the leaves during the first few minutes.

The tea plant is a shrub which grows chiefly in China, Japan, India, and Ceylon. The young leaves, which are the only parts used, are dark green in

colour, and glossy. They are not ready for use at once, but are treated in various ways by skilled workmen before being packed and exported.

Photo. Underwood & Underwood.

FIG. 37.—Coffee tree in bloom, Jamaica.

The coffee plant is also a small tree. It grows in many hot countries, but is cultivated chiefly in tropical America. In this case, as with the cocoa tree, not the leaves but the seeds form the valuable part of the

plant. The seeds (often called beans) are contained in bright red berries.

Coffee is most delicious when made with boiling water from freshly roasted and ground coffee beans. The freshening effect is due to a substance called caffeine, which is very similar indeed to the theine of tea.

When coffee is bought in the form of coffee beans the purchaser can be sure that it is not adulterated with chicory and other substances which are sometimes present in the ground coffee sold by dishonest dealers.

Cocoa contains a little of a substance which is very similar indeed to the theine of tea and the caffeine of coffee, and it has the same cheering and invigorating effect on the system. But while tea and coffee are drunk for the sake of this effect alone, cocoa is more valued for the food materials present in it.

Substances which rouse the body as a whole, or certain organs of the body, to greater activity for a time, are called stimulants. A great many strong stimulants are known to medical men, and are very valuable as medicines at times of great exhaustion and in certain other circumstances. As a rule it would be the height of folly, however, for ordinary people to use such stimulants, because many of them are poisons unless they are taken in very small doses.

One effect of nearly all stimulants, even when they are taken in small doses, is that their action is followed by extra weakness of the organs which were stimulated at first. Medical men know this, and allow for it, but other people might easily do themselves great harm by using strong stimulants.

Fortunately the stimulants contained in tea, coffee, and cocoa are gentle in their action, and their cheering effect is not usually followed by any corresponding depression.

Civilised nations naturally have a high opinion of these beverages, and all sensible people try to use them in the best manner. It ought to be understood, however, that tea and coffee are quite unnecessary for healthy children. Cocoa may be drunk without scruple because of the food materials in it.

LESSON XIX

ALCOHOLIC BEVERAGES

Beer, wine, and spirits all contain a poisonous substance called alcohol which in small quantities is a stimulant, acting at first much as the theine of tea and the caffeine of coffee act. At certain times, therefore, people might find a small quantity of beer or wine useful in taking away feelings of fatigue or heaviness.

Unfortunately the alcohol at the same time affects the brain and the rest of the nervous system in such a manner that they soon become less alert and sensitive. A person drinking more tea or coffee than is good for him immediately begins to feel uncomfortable, perhaps getting a headache, for his brain remains still in a condition to warn him that he is going to excess.

But a person drinking an alcoholic beverage is not

so clearly aware when the alcohol is beginning to injure him, because his brain is being dulled at the same time. Instead of having the warning feelings of discomfort, he becomes less and less aware of his real state, and therefore feels more comfortable even as he is doing himself more harm.

Indeed, one of the greatest dangers of drinking alcohol is that this substance dulls the nervous system so that all the best powers of the brain are injured. Anyone who thinks a little will realise that the finest qualities of men and women depend upon their ability to think properly. They know clearly what is going on around them; they consider a little whether an impulse is right and wise before they act upon it: as the saying is, "they look before they leap"; they are careful not to do anything which will injure other persons. They have free choice between right and wrong, and between wisdom and folly, because their brains are clear enough to know the differences between these.

On the other hand, the man whose brain is dulled is not in a condition to distinguish clearly between right and wrong, or between wisdom and folly. His impulses are not properly checked by his reason, so that he may commit acts of which he will be ashamed when his brain is fully active again. He is like a man who is not quite awake.

Little by little this loss of the best powers of the brain becomes the usual condition in all persons who make a habit of drinking alcoholic beverages to excess, even if the excess is so slight that no one would ever describe them as drunk. Their bodies are poisoned,

or intoxicated, notwithstanding. Indeed, the word intoxicated means "poisoned."

The poisoning of the system by alcohol affects not only the brain, but almost every other organ of the body as well, making it weaker, or in bad cases causing active disease to be set up in it. It also makes the body as a whole less able to resist the attacks of outside germs of disease.

It is clear, therefore, that although alcohol may be an extremely useful and indeed valuable stimulant on certain occasions of emergency, it is foolish to use it regularly because of the difficulty in knowing and stopping at the point when it becomes actively poisonous and injurious. Children especially ought never to drink anything containing alcohol, in however small amounts.

Alcohol is produced by a change which takes place in sugary liquids whenever yeast is allowed to grow in them. If some fruit juice be exposed to the air for a time, so that dust can fall into it, it will soon show signs of this change, which is called fermentation. The smell and taste of the fruit juice become unpleasant and somewhat suggestive of bad beer. This is because alcohol is forming in it. At the same time a froth collects on the surface; this is due to the escape of a gas, carbon dioxide. In this case the sugar necessary for the alcohol formation is obtained from the fruit juice; the yeast is present in the dust.

Now, there are many kinds of yeast. Those which occur in ordinary dust almost always give rise to disagreeable flavours when they set up fermentation. These are called wild yeasts. Other varieties, which

are present naturally on the skins of ripe grapes, apples, and some other fruits, cause the production of more pleasant flavours during the fermentation of the fruit juice. The fermentation of the juice of grapes in this way yields the various wines, that of apple juice yields cider, and so on.

Still other kinds of yeast are carefully cultivated, to keep them free from contamination by wild yeasts, and are used in the brewing of beer and stout. In this case the sugar used is that which, as we have learnt already, is formed in germinating barley seeds by the action of diastase on starch.

Many other alcoholic beverages are common in various parts of the world. However much they may differ from each other, they are alike in being produced by the action of some kind of yeast on some kind of sugary liquid. Various fruit juices, the whey of milk, the juice of the sugar cane, cocoa-nut "milk," and many other solutions are used for the purpose of obtaining intoxicating beverages by fermentation.

Spirits, such as brandy, whisky, rum, and gin, are formed from fermented liquors by driving off the alcohol by heat, as vapour, and then condensing it.

It is not necessary that we should know the details of the manufacture of these drinks, but it is necessary for us to realise that they all contain the poisonous alcohol, and are therefore all to be avoided. Spirits contain most of all, wines come next, and perhaps "light dinner ales" and lager beer contain least alcohol.

It is a curious fact that many people suppose claret, port, and home-made fruit wines to be free from danger.

It ought to be known that these liquids contain alcohol, and are intoxicating in exactly the same sense as the other fermented beverages mentioned above.

LESSON XX

RESPIRATION

In the preceding ten or more lessons we have been considering the nature and use of the materials which enter the body by the mouth. These make their way from the alimentary canal into the blood, in order to be carried to the various tissues, to be used as building materials.

We know that this building and repairing process is necessary, because every active tissue is continually burning away. We are aware that the burning is of a kind which produces only a gentle warmth, and is carried on in tissues which are always wet; but that it nevertheless causes a distinct loss of substance, which it is the object of food to make good.

We must next think carefully of something else which this burning away of tissue renders necessary; that is, the supply of air for the burning. For it is common knowledge that in every fire the air is as important as the fuel. Fuel without air would not keep a fire burning any more than air without fuel would.

Chemists tell us that it is only a certain portion of the air which thus takes a part in the burning process.

This portion they call oxygen. In every five cubic feet of ordinary air about one cubic foot consists of oxygen.

Oxygen, then, must be conveyed, by some means, from the air to the tissues requiring it. It is carried by the blood. In ourselves, though not in all living creatures, the oxygen enters the blood from the lungs. It does not, of course, go into the blood in its usual form, which is gaseous, but it dissolves in the moisture of the thin wet partition which separates the air in the lungs from the blood contained in the tiny blood-vessels near. In the tissues the blood again flows along vessels with walls thin enough to allow the dissolved oxygen to pass through them. Here the oxygen leaves the blood and enters the cells of the surrounding tissues, where the body fires are actually burning.

As the oxygen passes from the blood to the tissue-cells, certain waste products of the burning pass in the opposite direction, that is, from the tissue-cells to the blood. One of these waste products is a substance called carbon dioxide. Usually this substance exists in the form of a gas, as we already know. It is given off, as a gas, during the burning of every ordinary fire, and flies up the chimney. The life-fires of the body are peculiar, however, in being wet. The living fuel is wet, the oxygen comes to the fire dissolved in the blood, and the carbon dioxide leaves it also dissolved in the blood.

Nevertheless, when the blood comes again to the air of the lungs, the carbon dioxide passes into the air in its usual gaseous form, somewhat as the carbon

dioxide dissolved in soda water becomes a gas again and escapes into the air when the bottle is opened.

It is clear, therefore, that in our lungs an exchange takes place. The air in the lungs gives up oxygen to the blood, and at the same time the blood gives up carbon dioxide to the air. This exchange of waste carbon dioxide for fresh oxygen is called respiration, or breathing, and any part of an animal's body where the

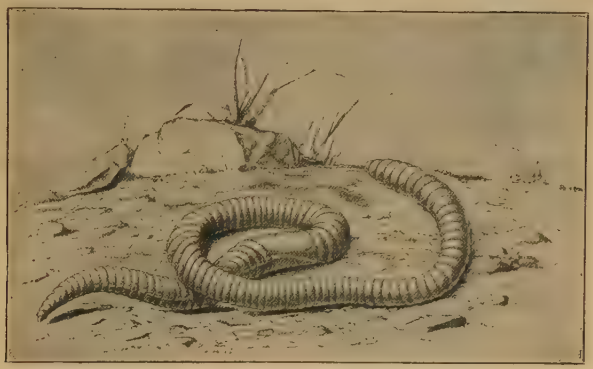


FIG. 38.—The earthworm breathes through its skin.

blood comes sufficiently near to a supply of fresh oxygen to let the exchange take place, is an organ of respiration, or breathing.

In ourselves, the lungs form the principal organ of respiration, but it is an interesting fact that a certain amount of breathing also goes on through our skins, wherever the blood gets close enough to the air to allow a little oxygen to pass in, and a little carbon dioxide to pass out.

In some animals the skin itself is so thin, and the blood comes so close to the surface, that the exchange

of gases takes place very freely, and the skin is the only organ of respiration. In the ordinary earthworm, for example, breathing is carried on entirely by the skin. The oxygen, of course, dissolves in the moisture of the skin in order to make its way into the blood.

With many aquatic animals it is not necessary that the organ of respiration should be supplied with ordinary air. The water of the sea, and of rivers, lakes, and ponds contains dissolved oxygen, which acts quite as well. Such aquatic animals as have skins which let their blood come very close to the surface may breathe this dissolved oxygen through their skins in a manner very similar to the earthworm's way of breathing.

FIG. 39.—The head end of a fish, with the gills exposed by removal of the flap which usually covers them.

Water-breathing animals, as such creatures may be called, are, however, often similar to ourselves and most other air-breathers in doing all, or nearly all, their breathing in one particular part of the body. This is always an organ which is much folded, or frayed out, or in some other way exposes a specially large surface where the blood can be brought close to the surrounding oxygen.

In some animals this breathing organ is found in very curious places. In ourselves and the animals most like us it takes the form of lungs, in which the surface is so much folded that the lungs are quite spongy. In fishes the organs of respiration are gills, which are frilled membranes on the margins of slits in the sides

of the neck. In lobsters the breathing organs are also called gills, but in this case they are feathery tufts at the sides of the body. Some creatures breathe with their tails, some with their legs; indeed, there is no region of the body which is not used by some animal or other for purposes of respiration. But in every case the breathing organ is a thin, moist membrane, with blood on one side of it and free oxygen on the other side.

It is easy to make a number of simple experiments which show the chief changes which take place in air whilst it is in the lungs of a human being. In the first place, the air is warmed, as may be shown by breathing on a thermometer. It also becomes moister, with water vapour given off by the blood; this moisture condenses to liquid drops when a cold surface is breathed upon.

The air breathed out from the lungs contains far more carbon dioxide that the outside air which enters the lungs. This may be shown by blowing the breath through a straw or a glass tube into a little clear lime water. The lime water becomes milky with fine particles of the chalk which is always produced when lime water and carbon dioxide come together. On the other hand, some clear lime water exposed to ordinary air only goes milky very slowly, because ordinary air contains only a small proportion of carbon dioxide.

Further, air breathed out from the lungs contains a much smaller proportion of oxygen than ordinary air contains. This may be made evident by filling a bottle with water, turning it upside down in water so that it still remains full, and then blowing the breath

from the lungs through a tube, the end of which is placed below the bottle-mouth. The air rises into the bottle and forces out the water, so that a bottle full of lung-air is easily got.

If now the bottle be taken away, put right side up, and a lighted taper be lowered into it at once, the flame will go out very soon because there is not enough oxygen in the bottle to let it burn well. But if, later, the taper be lowered into the same bottle when this is full of ordinary air it will burn much more brightly and not go out so soon, because so much more oxygen is present than before.

LESSON XXI

THE ORGANS OF RESPIRATION

In human beings the organs of respiration are, as we learnt in the last lesson, the lungs and the skin. Only a small part of the process is carried out by the skin, but respiration is so important that, if for the sake of this duty alone, it would be worth everyone's while to keep the skin clean and as healthy as possible. Of course the skin has many other functions besides that of respiration, and some of these will be studied in later lessons.

As respiration is the exchange of waste carbon dioxide contained in the blood for fresh oxygen from the air, it is clear that there must be some means of changing the air in contact with the respiratory

surface. For if no such arrangement existed this air would soon be deprived of all its available oxygen, and then respiration would stop.

The changing of the air in our lungs is brought about by the movements known as breathing. The

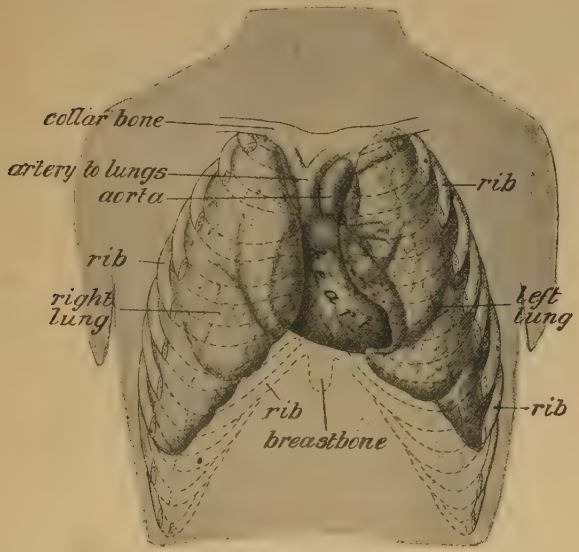


FIG. 40.—The heart and lungs in position in the thorax.

action of taking air into the lungs is called inspiration; that of driving air out of the lungs is called expiration. In order to understand these movements we must learn something of the manner in which the lungs are situated in the body.

The two lungs are contained in the upper chamber of the body cavity. This is called the thoracic or

chest cavity. It is separated from the lower chamber (the abdominal cavity) by a dome-shaped partition known as the diaphragm (Fig. 41). The heart also is contained in the thorax; it lies between the two lungs.

The lungs communicate with the outside air by the windpipe, a gristly tube, which can be felt through the skin, in the front of the neck. At the base of the neck the windpipe divides into right and left tubes, called the bronchi, which enter the right and left lungs respectively. The bronchi branch repeatedly. Their smallest branches are very fine indeed, and each opens into a tiny bag, in the walls of which are extremely small blood-vessels.

These bags are called air-sacs. It is through their walls that the actual exchange takes place between the air and the blood, for nothing now separates the two but the thinnest of moist partitions. There are thousands of air-sacs in each lung, and by this arrangement the blood is exposed to the air over a far greater surface than would be possible if the lungs were merely simple bags.

To keep the air passages always open, the windpipe, the two bronchi, and their main branches are stiffened by incomplete rings of cartilage. These can be felt through the skin of the neck; except in the larynx or voice-box they are C-shaped. In the smaller branches of the bronchi the stiffening cartilages are in plates, but they act in exactly the same way and keep the air tubes open.

The covering of each lung is a very smooth membrane called the pleura. Where the bronchi and

the great blood-vessels enter the lungs this membrane is folded back to line the inside of the chest-wall. The layer of pleura forming the surface of the lung, and the layer of pleura lining the thoracic cavity, are in close contact with each other, so that the lungs

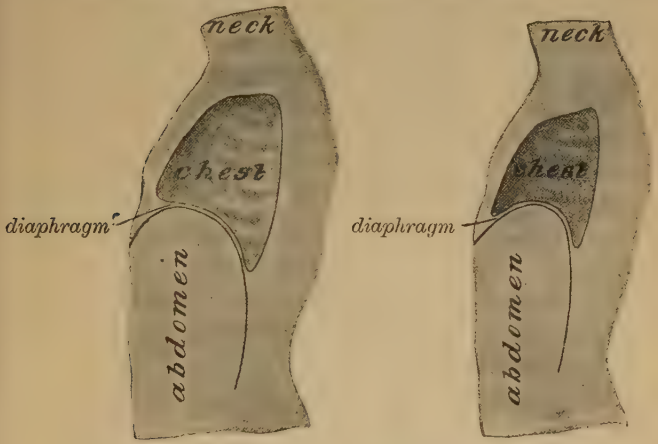


FIG. 41.—The changes in the size of the chest during breathing. On the left, after inspiration; on the right, after expiration.

always fit very exactly to the wall of the chest and move with it.

To understand what these movements are we must bear in mind, first, that the side walls of the thorax or chest are supported by the ribs, which are movable. It will be remembered that at the back the ribs are hinged to the thoracic vertebrae, so that they can be raised by the action of muscles attached to them. In front, most of them are attached to the sternum or breast bone. In the position of rest the front end of each rib is at a lower level than

the back end, and it follows that the raising of the ribs pushes the breast bone outwards, and so increases the size of the chest cavity as measured from front to back. Also the ribs are curved in such a way at the sides that the act of raising them pushes the chest-wall out at the sides as well.

Whilst the ribs are being raised in this manner, the diaphragm, which forms the floor of the chest, is also moving. This dome-shaped muscle becomes somewhat less arched, so that the chest floor is lowered at the same time that its front and side walls are being pushed outwards. The lungs remain closely in contact with the walls and floor, and therefore follow their movements and become larger. To fill this increased space in the lungs, air immediately flows through the nostrils, down the windpipe and along the bronchial tubes.

All this, which has taken so long to describe, is completed in perhaps one second. It forms one inspiration. Immediately, all the contracted muscles which have been acting relax again, parts which have been stretched return to their former shape and size, and an amount of air equal to that inspired is forced out. The expired air, however, has, as we know, a composition very different from that of the inspired air. After the expiration there is a slight pause before the next inspiration.

An adult man or woman breathes about sixteen times a minute in ordinary circumstances, but the rate is increased by active exercise or excitement. Children breathe more quickly and also more irregularly.

The amount of air in the lungs of a man after

an ordinary inspiration is usually about 230 cubic inches, but in quiet breathing he only changes about 30 cubic inches of this. That is, only one-seventh of the air in his lungs is ever pure. By very deep breathing, however, it is possible to change as much as 230 cubic inches of air, out of a total capacity of 330, at each breath, and therefore to increase very largely indeed the proportion of pure air in the lungs.

It is not necessary, or even advisable, to breathe at all times as deeply as possible, but to take a deep breathing exercise several times a day is an excellent practice. It expands the lungs and helps to keep the whole machinery of respiration in good working order.

Free breathing is impossible to anyone wearing tight clothing, either on the chest or round the waist. Children naturally use the diaphragm much more than the ribs in breathing. Men also make a great deal of use of the diaphragm, but they rely in addition upon the helpful movements of the ribs to a greater extent than children. Women usually employ their upper ribs more, and their lower ribs less, than men for the movements of breathing. Ignorance and the too tight clothing of the waist region are both responsible for the bad habit of what is called "high-chest breathing" in so many people, especially women. People breathing properly, so that their lungs are making the best use of their powers, can feel the diaphragm sink and press firmly on the organs of the abdomen at each inspiration.

LESSON XXII

OTHER USES OF BREATHING

ALTHOUGH by far the most important object of the alternate inspiration and expiration of the breath is the changing of the air in the lungs, these actions have other interesting uses also, to which it will be well to refer now.

As the breath is taken in through the nose it passes over some delicate skin which is very sensitive to the presence of certain substances in the air. Nerves in connection with this skin convey to the brain information of the manner in which this skin has been affected, and so give rise to the sense of smell.

It is not difficult to understand that the sense of smell is a great advantage to us. It often lets us know of the presence of things which are out of sight and are not making any sound. The smell may be a disagreeable one, and we at once try to remove the cause or else to go away from it. To breathe through the mouth in order to avoid the smell, and then to ignore the cause of the smell, is extremely foolish. It should be remembered that something with an unpleasant smell is nearly always harmful, and our natural impulse to avoid it is therefore a useful one.

The smelling skin, as we may call it, of the nose covers certain thin rolled-up bones in the upper part of each of the chambers which are situated between the nostrils and the back of the throat (Fig. 42). When we wish to smell something more distinctly, we

sniff and draw more air than usual over this sensitive skin.

This membrane is kept always moist by a sticky fluid called mucus, and any particles of dust contained in the inspired air are very likely to be caught in the mucus. Instead of going forward to the lungs to choke up the fine air tubes, to interfere with perfect respiration, and to introduce the germs of disease, most of the dirt, therefore, stays in the nose and can be removed easily with the handkerchief. The fine hairs which usually line the nostrils are also useful by keeping back dirt.

The inspired air is not merely purified in this way in its passage through the nasal chambers; it is also warmed, and even in cold weather it reaches the lungs at a temperature which is not likely to cause a chill.

All these advantages are lost by people who breathe through their mouths. The useful warnings of unpleasant smells are lost, and the pleasures to be had from the scents of flowers and food are missed; the delicate lungs are exposed to all the dangers which lurk in dust, and the liability to take severe cold is greatly increased.

In many cases the harmful practice of breathing through the mouth, even during sleep, is merely a bad habit, which may be broken by a determined effort of the will. People who have this habit ought to realise that the question is one of great importance, affecting not merely the expression of the face but also the health of mind and body.

There are some persons, however, who are prevented from breathing properly through the nose by the

presence of swellings called adenoid growths, where the hinder end of the nasal chamber opens into the top of the throat (Fig. 42). This region is called the pharynx. If, therefore, any person finds it difficult or impossible to breathe with the mouth closed a doctor

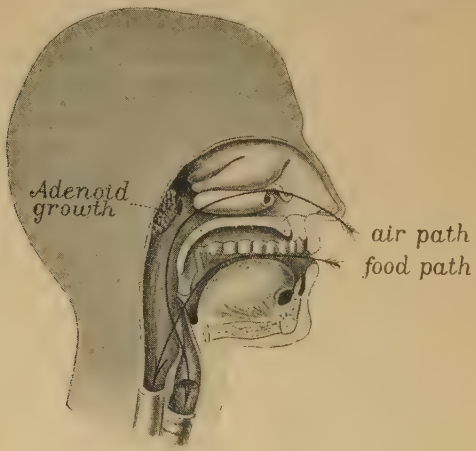


Fig. 42.—The upper parts of the air path and the food path. An adenoid growth is shown in the hinder part of the nasal chamber.

should be consulted. If adenoids are found to be causing the obstruction, they can be removed by a simple operation, with great improvement of the general health and comfort.

Breathing is also connected to some extent with the sense of hearing. On each side of the head a little tube, called the Eustachian tube, opens from the inside of the ear into the pharynx. It is of use for keeping the air under the ear drum at the right pressure: when the tube becomes inflamed and blocked up, as

often happens during a cold, the hearing is interfered with.

Important as are the other functions with which the act of inspiration is associated, there is one connected with expiration which far outweighs them all. This is the production of voice and speech. It enables us to speak to one another and so share one another's thoughts and knowledge. More than any other power it accounts for the success of the human race.

The larynx or voice-box is in the upper part of the windpipe. It is supported by certain cartilages hinged

FIG. 43.—View of the human larynx from above as actually seen by the aid of the instrument called the laryngoscope; A, in the condition when voice is being produced; B, at rest when no voice is produced.

together in a peculiar manner and moved by muscles. The inside lining of the larynx consists of a kind of delicate skin which is continuous with the rest of the lining of the windpipe. At one level, however, the skin forms two flaps, one at each side (Fig. 43). These flaps can be stretched across so as to leave only a narrow chink between them (Fig. A), or they may remain wide apart and leave ample room for the passage of the air when the voice is not being used (Fig. B).

The flaps are called the vocal cords. By move-

ments of the cartilages to which they are attached they may not only be made to alter their position in the manner just described, but also may be stretched to different degrees of tightness.

If the vocal cords are side by side, separated only by a narrow chink, the passage of the expired air between them causes them to quiver, or vibrate, and produce the sound known as the voice. The pitch of the voice varies in any given person according to the tightness with which the cords are stretched. More tightly stretched cords yield a higher note. Some of the movements of the cartilages to produce different degrees of tightness of the vocal cords may be seen easily by a person standing in front of a mirror and singing scales. The pitch of the voice also depends on the length of the vocal cords. They are longer in men than in women and children, and men have deeper voices for that reason. It is the sudden increase in size of the larynx and lengthening of the vocal cords of boys about the age of 14 which causes the change of voice known as "breaking." Boys ought not to sing much at this period, as the voice may be spoiled by overworking the larynx during the change.

The musical quality of the singing voice depends greatly upon the size and shape of the cavities of the mouth and pharynx; and as these are largely under the control of voluntary muscles it follows that people may be trained in what is called voice-production, and be taught how to obtain the most pleasing effects with the least effort and fatigue.

The proper training of the speaking voice is also important, even for persons who do not intend to be

public speakers. People whose articulation is clear, and whose intonation is musical are naturally more pleasing to others than those who speak indistinctly and in a harsh voice. There is no more marked difference between the cultured and the uneducated classes than that shown in the manner of speaking.

FIG. 44.—Diagrams to show the alterations in the mouth cavity in the pronunciation of the vowel sounds A, E, OO.

The alteration of the shape of the mouth cavity in the production of different vowel sounds is made very clear by the singing of the vowels *ah*, *eh*, *ee*, *aw*, *oh*, *oo* in succession. The exercise shows that not only the cheeks but the tongue and lips are used to modify the sounds (Fig. 44).

Consonants are the result of a complete or partial interruption of the current of air for a moment. *P* and *b* are formed by momentary closing of the lips, *t* and *d* by interrupting the flow by the tip of the tongue, and *k* and *g* by stopping the breath with the back of the tongue and the roof of the mouth.

The method of formation of such consonants as *f* and *v*, *s* and *z*, *r*, *m* and *n*, *th* and *s* is not quite so simple, but can nevertheless be understood easily by anyone who will think a little about this interesting subject.

LESSON XXIII

THE DANGERS OF INSUFFICIENT VENTILATION

The air of rooms in which persons are living, or in which any burning process is going on, soon becomes unfit to breathe. The air of such rooms ought, therefore, to be replaced regularly by pure air from outside; in other words, the rooms ought to be ventilated. These facts are known to everybody, but their great importance is not realised until it is understood why impure air is bad for the health.

We know that our life and health depend upon the proper combustion of our tissues, and that no combustion can take place in the absence of oxygen. Clearly, any circumstances which make the proportion of oxygen in air less than usual must also cause the fire of life to burn less brightly than usual: must, that is to say, lower the vitality of the whole body, or make it less alive. It is evident, then, that the lack of oxygen is in itself sufficient to injure the health of persons spending much time in badly ventilated rooms.

As the proportion of oxygen in a room becomes less, that of carbon dioxide becomes greater, because the

same fires which are using up the oxygen are at the same time producing carbon dioxide. This is the case whether the fires are those of living bodies, or those of burning coal, gas, oil, or candles; and it is worth while to notice here the absurdity of the statements sometimes made that certain stoves do not pollute the air, and therefore require no flue to carry off fumes.

The gases produced by the burning may be quite without smell, and indeed carbon dioxide is without smell, but they are produced none the less, even in the most perfect forms of stoves, and are continually using up the oxygen and adding to the carbon dioxide of the room unless a flue carries off the products of combustion.

It is believed that amounts of carbon dioxide such as ordinarily occur in ill-ventilated rooms are not in themselves injurious. The harm is due rather to the lack of oxygen which always accompanies the excess of carbon dioxide.

A badly ventilated room in which many people have remained for a considerable time has a much more offensive odour than a badly ventilated room in which burning gas or candles alone have used up the oxygen to the same extent. The difference is due to the small particles of animal matter which are being continually given off from the lungs of even healthy persons in breathing. These particles quickly decay and produce what is sometimes called the "crowd smell." This animal matter in the air is more injurious even than the oxygen starvation which always accompanies it, because it actually poisons the persons breathing it.

If, then, healthy persons are always poisoning the air around them, how much worse must be the contamination of the air produced by the breathing of persons suffering from disease. Such air does not merely weaken the system by oxygen starvation, and poison it with decaying organic matter, in many cases it conveys the actual germs of disease as well.

If people realised these facts they would insist, at all costs, on breathing the purest air to be got. They would live as much as possible in the open air, and when they were compelled by work or other circumstances to be inside rooms, they would take care that the rooms were properly ventilated.

It is necessary to point out the errors in certain ideas which many people have on the subject of ventilation and the purity of air. One of these ideas is that cool air is always purer than warm air. This is quite wrong: the purity of air has nothing whatever to do with its warmth. Cold air may be purer or more impure than warm air, according to circumstances. It is, however, unhealthy, for other reasons, for people to live in rooms heated to a temperature much above sixty degrees on a Fahrenheit thermometer, especially when the outside air is much cooler than this.

Another mistaken notion which is still widely held is that night air is unhealthy. What is meant by the saying is, of course, that the open air is unhealthy at night. Except in countries where malaria is common this is the exact opposite of the truth. Malaria, however, is spread by the "bites" of certain mosquitoes which fly abroad at night.

It is becoming more and more common for intelli-

gent people to keep the windows of bedrooms open night and day, winter and summer, except in malarial districts. If their bodies are well covered they are in no danger of taking cold at night, especially if they breathe through the nose, as of course all sensible people do who have learned the importance of this.

The complaints known as "colds" are, as a matter of fact, passed on from one person to another by invisible germs. At any time when our bodies are in such a low state of health as may be produced by breathing impure air, we are liable to "take cold," even in hot weather. In the frozen arctic regions "colds are reported as rare or unknown, although changes of temperature are often frequent and large."[1] This interesting fact is accounted for by the purity of the air, and especially by its freedom from disease germs.

Persons who live in towns are, of course, always exposed more or less to the germs of certain diseases which are carried in the air, but it should be remembered that the open air is always freer from such germs than the air of rooms. Even in towns the danger of infection is very small for persons who take care of the general health, avoid sudden chills, breathe regularly through the nose, and—above all—avoid stuffy rooms.

Diseases of the air passages and lungs are largely due to neglect of these simple rules. Bronchitis is inflammation of the bronchi, which, as we have learnt, are the larger branches of the windpipe. Pleurisy is inflammation of the pleurae, the smooth layers covering

[1] Ward's *Climate* (Murray).

the lungs. Pneumonia is inflammation of the lungs. These complaints, like sore throats, may often be traced to the effects of breathing through the mouth. Had the sufferer breathed through his nose only, the air would have been made more free from disease germs as well as warmed, and he might have escaped the illness. It is more necessary than ever, in very cold weather, to avoid breathing through the mouth.

FIG. 45.—The germs of consumption, as seen through a microscope, magnifying 1000 times in every direction.

Lastly, the terrible disease of consumption, which has been called "the great white plague," is also due to a germ which is very often present in the air, especially in that of rooms. We are all exposed to this danger from time to time, but we can do much to escape harm from it by following the rules of health. Pure air is of great importance in the fight with all diseases, but it is in the fight with consumption—perhaps the worst disease of all—that its value is greatest. Nothing else so surely protects us from consumption, nothing else is of so much use in the treatment of its victims, as the constant breathing of pure air. It is our duty to live as much as possible in the open air; it is equally our duty to help to keep the air pure for others, especially by

abstaining from spitting in public places; and, when we become old enough to have a voice in the government of our district, by encouraging the growth of trees, the preservation of open spaces, and the building of only properly planned houses.

LESSON XXIV

THE CLEANSING OF THE TISSUES

A NECESSARY result of the burning of a coal fire is the production of waste matters. Some of these fly up the chimney as invisible gases. Others remain visible as black smoke and cinders. Yet others consist of sandy materials and the like which have taken no part in the burning, but were, so to speak, mere adulterations of the useful fuel.

It will be well to notice that these waste materials are of three kinds. The first kind consists of material which is completely burnt. Carbon dioxide and water vapour are materials of this kind which are always formed whenever coal (or any other fuel of vegetable or animal origin) burns.

In the second group, smoke or soot, and coke or cinders may be placed. These consist of what may be called partly-burnt fuel; they could be made to yield more heat by further burning. It is because our fireplaces and stoves are not yet perfect in design that combustion in them is so incomplete as to produce smoke and coke. Perhaps there will be invented some

day a form of fireplace which will burn the fuel so completely that neither smoke nor coke will be formed.

In the third class of wastes we have the ashes, which have not been produced by the burning of anything. These materials were in the coal at first, and they have merely become more noticeable because the real fuel has burnt away and left them behind.

Everyone who has attended to a fire knows how necessary it is to remove all these materials regularly. The chimney must be kept open to secure a good draught; it must be swept clear of soot from time to time for this purpose; and the cinders and ashes must also be removed.

These simple considerations throw a great deal of light on the methods of removal of the waste materials which are formed by the burning of the fire of life. The fuel is the living tissue of the body, which in very many respects burns like coal: indeed, we know that a piece of meat would burn easily, and take the place of a piece of coal, in a fire.

The waste substances which are formed in the body are very similar in many ways to those formed in a coal fire. The activity of the body forms carbon dioxide and water as the coal fire does. It also forms partly-burnt waste, which may be roughly compared to smoke and cinders. All these waste products of the body's activity are called excretions.

The indigestible matters left in the bowels are different, because they never formed any part of the living tissue of the body; they are not produced by any process of burning, and they are therefore not excretions. They are to be compared with the useless

sand or clay mixed with coal. Such indigestible materials are got rid of by the daily action of the bowels.

It is with the waste materials properly called excretions that we are concerned at present. They are produced in every active tissue. A considerable amount of carbon dioxide is, for example, produced by the muscles when they are working actively, and passes from them directly into the blood. Such excretions must be carried regularly by the blood from the tissues to places where they can be discharged from the body. Such discharging places are called excretory organs, and the work which they do is called excretion.

The giving off of carbon dioxide we have already learnt to regard as a very important function of the lungs, Combined with the taking in of oxygen, it constitutes respiration. It is evident that half of the process of respiration is of the nature of excretion, and that therefore every respiratory organ must also be an excretory organ.

This, however, is not the only respect in which the lungs are excretory organs. They also give off a large amount of water in the form of vapour, as is made evident by the drops of liquid water which are condensed when we breathe on a cold surface.

Another excretory organ of very great importance is the skin. We know already that it is respiratory to a slight extent, and therefore excretes a little carbon dioxide. This duty of the skin is small, however, in comparison with its work of excreting waste water in the form of perspiration or sweat

The sweat is extracted from the blood in the part of

the skin which is next the underlying flesh. Here are the closed and coiled-up ends of more than two millions of little pipes, called sweat ducts, the other ends of which open on the surface of the skin. The open ends of some of the sweat ducts are easily seen on the palm of the hand with the help of a good magnifying glass, especially when the hand is perspiring a little.

FIG. 46.—Thin slice through human skin, magnified. The coiled tube on the left is a sweat gland with its duct. To the right of this is shown a hair, with its oil glands.

The blood comes to the coiled, closed end of each sweat duct through a little artery, which branches into a network of extremely fine tubes surrounding the coil.

The unnecessary water of the blood, with a little salt in solution, makes its way through the walls into the duct and passes along it to the surface of the skin, where it evaporates. The trace of solid matter dissolved in the sweat is left behind on he skin.

Whenever a liquid evaporates, it absorbs heat from any surface which it may be touching, and the surface naturally becomes cooler. The evaporation of sweat therefore cools the body.

Now it happens that at certain times the small arteries of the skin (which bring the blood supplying water to the sweat ducts) become wider. The result is a more abundant supply of blood to the skin, a more

abundant discharge of sweat, and a greater cooling of the body. This change takes place, in healthy people, whenever the body is becoming overheated, either by active exercise or otherwise. The excretion of water by the skin is thus made to serve another purpose as well. It regulates the temperature of the body. If the sweat is discharged more quickly than it evaporates, the skin becomes wet. It should be remembered, however, that some amount of sweat is always being excreted by the skin. If it evaporates at once, it naturally does not cause the skin to become wet.

It is clear that if an extra supply of blood were sent through the small arteries of the skin when there was no overheating of the body, an injurious chill might result from the rapid cooling produced by the evaporation of the increased sweat. This is one of the dangers of drinking alcoholic beverages in cold weather. The alcohol causes the small arteries of the skin to dilate or widen and bring extra blood to the sweat glands.

In cold weather the skin arteries of healthy persons are narrowed or constricted and allow the passage of only a small quantity of blood. The constriction is caused by the contraction of involuntary muscles in the walls of the arteries.

Plainly, if we can keep the muscles of the skin arteries in good working order we have a means of protecting the body from dangerous loss of heat in cold weather. There is no surer way of exercising them than by sponging the skin with cold water each morning on rising from bed. The arteries then get into the habit of changing in size at once, when the

body is exposed to a change of temperature—dilating on greater warmth, constricting as a result of cold.

Such cold sponging is, of course, not of much use for keeping the skin clean. This is just as necessary, in order to keep the pores of the sweat glands open. To cleanse the skin, thorough washing with soap and warm water is necessary at least once a week.

LESSON XXV

THE CLEANSING OF THE TISSUES (*Continued*)

We must next learn about the partly-burnt waste of the human body—the part which may be compared with the soot and coke produced during the burning of a coal fire.

The most important of the waste products of this kind is called urea. Besides being, as it were, only partly-burnt fuel, urea differs from the carbon dioxide and water in various other respects. For one thing, it contains nitrogen and they do not. In fact, almost all the nitrogen which enters the body in the form of proteid matter leaves it in the form of urea. Urea is also very unlike the other excretions in appearance, being a white solid, something like common salt, when separated from everything else.

The organs which discharge urea from the body are the two kidneys. These are very similar in shape and general appearance to the kidneys of a sheep. The

kidneys of a man are, however, rather larger than those of a sheep.

The human kidneys are in the back part of the abdominal cavity, one on each side of the middle line. To the inner side of each is connected a long white tube called a ureter. The two ureters lead to a bag, the bladder, which lies in the lower part of the abdominal cavity (Fig. 47).

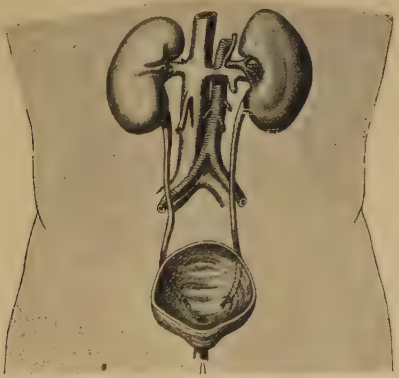


FIG. 47.—The kidneys, ureters and bladder, with the blood vessels connected with the kidneys. The bladder is shown cut open to expose its interior.

The work of the kidneys, then, is to extract urea, water, and certain other waste matters from the blood coming to them, and to pass these waste matters along the ureters to the bladder. From this bag they are expelled from the body.

We see, therefore, that although each of the excretory organs—the lungs, the skin, and the kidneys—is chiefly concerned with ridding the body of one special kind of waste, it also takes a share in cleansing the

body from some other impurity. Thus the lungs have the important function of excreting the waste carbon dioxide, but they also give off a great deal of water in the form of vapour. The special excretory work of the skin is the discharge of water, but it also gives off a certain amount of carbon dioxide. The great duty of the kidneys is the excretion of nitrogenous waste, but with it a large quantity of waste water passes out of the body.

A particularly interesting example of the assistance which the various excretory organs lend each other is seen in the case of the skin and the kidneys. In hot weather the skin gives off more water than usual, for reasons which we considered in the last lesson; as a consequence the kidneys pass less water than usual. On the other hand, during cold weather perspiration is usually less than at any other time; to make up for this, the amount of water excreted by the kidneys is greater. The amount of urea which leaves the body, however, does not vary in this way; it remains very much the same whether the amount of water lost by the kidneys is large or small.

As we have learnt, urea is the form in which the waste nitrogen leaves the body. It is, therefore, very strange that although most of the nitrogen contained in the body is present in the muscles, there is little or no increase in the amount of urea excreted during hard muscular work, but a considerable increase in the amount excreted during the following two or three days.

Urea is formed in the liver. From the liver it is carried by the blood to the kidneys, which promptly excrete it. Urea itself is not poisonous; but the

waste nitrogenous substances from which it is formed are injurious; and if these waste matters are retained in the body without being changed into urea (owing to imperfect action of the liver or otherwise) they act as poisons—especially to parts of the nervous system —and very serious illness is produced. Not only may disease prevent the liver and kidneys from doing their work of forming and excreting; it may also cause them to excrete from the blood valuable materials, such as sugar or albumin, which ought to have been used for nourishing the body.

In previous lessons we have learnt the great importance of the work done by the liver in preparing the digestive fluid bile, and also in storing for a time of greater need some of the surplus food which is often eaten. We see now that this organ must also be considered an assistant excretory organ, because it forms urea.

There is still another side to the usefulness of the liver. The bile contains other substances besides those active in the digestion of fat. Some of these appear to be impurities removed from the blood. Others prevent the food in the intestines from fermenting and producing poisons readily. That part of the food which is left in the bowels, after the useful part has been absorbed, always becomes injurious unless it is expelled daily from the body, but it would be much more offensive and poisonous if it were not for the action of the bile upon it.

Although the regular removal of this useless part of the food—which has been compared to the stones, sand, and clay which may occur in coal—is necessary

for the body's health, it does not really form an example of the cleansing of the tissues, which is the subject of this lesson ; for, as we know, this undigested material has never taken any part in the life of the tissues.

LESSON XXVI

THE DUTIES OF THE BLOOD

In most of the foregoing lessons some reference has been made to the blood ; and we already know enough of the workings of our bodies to understand that the health of every part depends very largely upon the successful performance of the duties of the blood. It is time to learn more definitely what these duties are, and how they are carried out.

The chief duties of the blood are :

(1) To carry food from the alimentary canal to the tissues.

(2) To carry oxygen from the respiratory organs to the tissues.

(3) To carry the waste products of activity from the tissues to the excretory organs.

When we realise that the blood is above all the carrying agent of the body, we immediately begin to wonder how, in the first place, it takes up and lays down its burdens ; and how, in the second place, it is moved along in the proper directions and at the proper speed. In this lesson we shall learn, among other things, the answer to the first of these interesting

questions. The second question will be dealt with in the next lesson.

It is clear at the outset that materials cannot enter, or leave, the blood where it is flowing through the thick-walled and tough pipes, or vessels, which are called arteries and veins. In such places the blood is quite shut off from its surroundings. Also, it must be remembered that there are nowhere any holes in the vessels' walls through which materials can pass into or out of the blood. The only manner in which anything can enter, or leave, the blood is by soaking through the walls of the blood-vessels, and this is only possible where the walls are very thin and delicate indeed. Although the walls of arteries and veins are made of materials quite unsuitable for this, the arteries and veins are connected with each other by still smaller blood-vessels, called capillaries, which have extremely thin walls. Dissolved gases, digested foodstuffs, and dissolved waste, pass without any difficulty through the walls of the capillaries.

We shall look upon capillaries then as acting somewhat as docks in the river or canal systems of a country. Nowhere else can any goods be shipped or unshipped. The river system we are talking of is, of course, the system of blood-vessels, and the country is the living body.

The capillaries are very fine tubes indeed; too fine to be visible to the naked eye, so that even the finest blood-vessels seen in preparing, say, a rabbit for dinner are much larger than the capillaries. Two thousand or more placed side by side would only cover a width of one inch. Through the microscope, however, it is

possible to see them easily in any transparent part of a living animal, as, for example, in the web which joins the toes of a frog's hind-foot, or in the tail of a tadpole.

Fig. 48.—Capillaries, and the small arteries and veins with which they are connected, as seen in the web of a frog's foot with the aid of a microscope.

It is then easy to watch the blood flowing like a stream along each capillary, and anyone enjoying this fine sight soon notices other facts as well. The rushing blood-stream seems to be merely a channel in the tissue; though there really is a very delicate membrane separating the blood and the tissue, this is scarcely to be seen even with the microscope; and the observer has no difficulty in understanding how easily materials can pass either from the blood to the tissue, or from the tissue to the blood.

Another interesting fact which at once takes the attention is the nearness together of the capillaries. Indeed, they form a network of so close a mesh that it is plain that every part of the tissue can share in the good things brought by the blood, and can easily be relieved of its rubbish by the blood.

Also the blood flowing along the capillaries is seen to be much paler in colour than anyone would expect from the deep red of blood seen by the naked eye. And by this time, too, the observer will have noticed

that a large number of solid particles are being whirled along the stream in every capillary. He will find that the speed of the stream will prevent him from getting so clear a view as he would like of these particles.

To see the blood at rest and examine it leisurely, one places a drop of blood upon a slip of glass and covers it with a second and much thinner glass slip, so that the drop is spread out into a very thin film. By means of a microscope magnifying the appearance of objects 400 or 500 times in every direction, it is easy to make out many interesting facts difficult to recognise in moving blood.

The liquid part of blood is called plasma. It is nearly colourless. Suspended in the plasma are certain solid bodies. Most of these, in human blood, are yellowish pink in colour, and in shape somewhat like muffins. They are called red corpuscles, because the ordinary red colour of blood is due to the deep pink colour produced when myriads of them are seen together. A very small drop of blood may easily contain five millions of them. In blood drawn from the arteries the red corpuscles tend to arrange themselves with their flat faces together, like piles of coins.

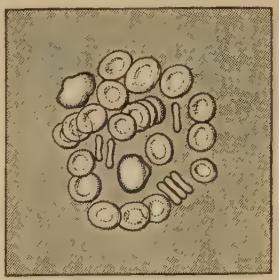


FIG. 49.—Blood corpuscles magnified 400 times. Two white corpuscles are shown.

The other solid particles are much less numerous, slightly larger, irregular in shape, and without any

particular colour. They are called the colourless corpuscles, or sometimes the white corpuscles.

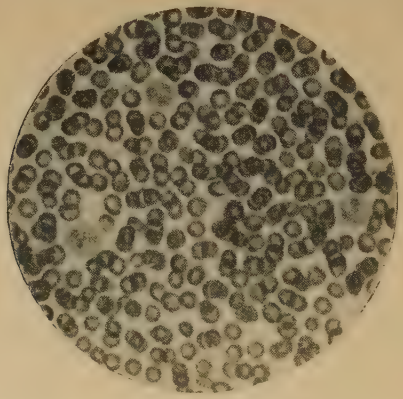


Fig. 50.—Blood seen under the microscope. (From a photograph.)

The red corpuscles, the white corpuscles, and the plasma all have their special work to do to help to keep the body healthy. The special work of the red corpuscles is to carry oxygen from the lungs to the tissues. It is the red colouring matter which holds the oxygen, but it readily parts with it as the blood flows along the capillaries of tissues needing oxygen.

Fig. 51.—White Corpuscles.

The white corpuscles do work which is even more wonderful. One of their duties is when necessary to creep out of the capillaries into the tissues, and to attack and devour any disease germs which may have invaded the body. If the general health of the body is low, the white corpuscles may

not be successful, but they always fight their hardest against the enemy.

Another duty of the white corpuscles is exercised when the blood is exposed to the air. Then they give off something which makes the plasma stiffen—or, as we say, clot—somewhat as white of egg stiffens when it is boiled. Now, the blood of a living animal is not usually exposed to the air except at a wound, and we know that the clotting of blood at a wound helps to seal up the cut and stop the bleeding.

The special work of the plasma is to carry the digested food to the tissues, and to carry waste matters from the tissues to the excretory organs. Also, as it is the liquid part of the blood, it helps all the work of the corpuscles by carrying them about from place to place.

Naturally, more or less of the plasma oozes through the capillary walls into the surrounding tissues. Such escaped plasma is known as lymph. Much of this lymph soaks back again through the thin-walled capillaries, as it is needed; and a part gradually finds its way into channels called lymphatics, by means of which it is presently carried to a place at the root of the neck and discharged into a vein, so that it is not lost.

Only the principal duties of the blood have been described in this lesson. There are, however, a few others. We know, for example, that the heat produced in the burning of an active tissue warms the blood, and this heat is thereby distributed to all parts of the body, much as the heat of a furnace is often carried round to all parts of a large building by means of hot water flowing through pipes.

LESSON XXVII

THE HEART

In this lesson we are to learn something of the wonderful machinery which drives the blood steadily round the body, so that it may perform the important duties which have been just described.

Fig. 52.—The heart of a sheep, in position between the two lungs.

This machinery consists of two pumps and a great system of branching pipes connected with them. The two pumps make up the heart; the branching pipes are called arteries and veins. The arteries are the blood-vessels through which blood flows *away* from the

heart towards the capillaries; the veins are the blood-vessels through which blood is returned from the capillaries *towards* the heart.

The heart lies between the two lungs, in the middle of the cavity of the chest (Fig. 52). It is about as large as the closed fist of the person to whom it belongs. In shape it is conical, the base being upwards and the point downwards, and turned a little to the left.

Although the two pumps of which the heart is composed are so close together, one on the right and one on the left, they are quite separated by a partition which does not allow blood to pass directly from one to the other. Indeed, the two pumps could probably do their work quite as well if they were in different parts of the body.

Each pump contains two cavities, an upper chamber called the auricle, into which blood flows from certain veins; and a lower chamber called the ventricle, out of which blood is forced along certain arteries.

The arrangements for keeping the blood moving in the proper direction are much the same on each side of the heart. The walls of both auricle and ventricle consist of muscle, which contracts in such a way as to make the cavity less, just as the cavity of an india-rubber syringe is made less when the syringe is squeezed. And just as the water in a syringe is forced out of it by the squeezing, so the blood in the auricle or ventricle is forced out by the contraction of its muscular walls.

In what is called one "beat" of the heart, the auricles of the pumps contract first, then the ventricles

contract, then comes a slight pause. The pause is very short, but it gives the muscles time to rest before the contractions begin again. It is plain that blood will be driven out of each chamber at the moment of its contraction.

The direction of the flow is decided by an arrangement of valves shown in Fig. 53. The valves

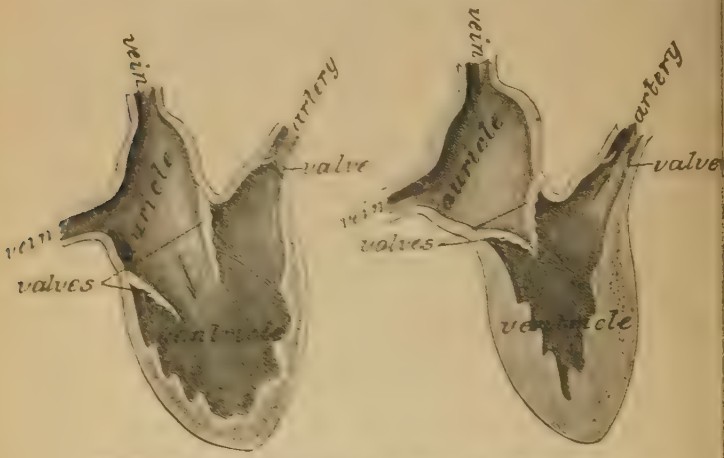


Fig. 53.—Diagrams of one pump of the heart. In the left figure the blood is flowing from the auricle into the ventricle. In the right figure the ventricle is contracting.

between the auricle and the ventricle are flaps of skin (three in the right pump, two in the left), which are tied by tough cords to the wall of the ventricle. The pressure of the blood, when the ventricle contracts, forces these flaps together and closes the way back into the auricle. The cords (which remain tight) prevent the flaps from being forced through into the auricle.

The blood cannot get back into the auricle; its only possible path is into the artery which is in connection with the ventricle; and the pressure of the blood quickly becomes great enough to force open the three pocket-like valves at the base of the artery. At first these valves are tightly closed by the pressure of the blood already inside the artery, and they close again the moment the new blood has passed through.

The emptied ventricle relaxes again; the valves separating the auricle and ventricle open once more, for there is nothing to keep them closed; and the contraction of the auricle—which in the meantime has received a fresh flow from the veins—quickly fills the ventricle with blood again. This wonderful action goes on regularly throughout our lives, about 70 times a minute in an adult man. In infancy and childhood the heart beats more rapidly.

The work of the pump on the right side of the heart is to receive the blood returning from the tissues, and pump it through the artery which branches to supply the capillaries of the lungs. In these capillaries the blood gives up carbon dioxide and takes in a fresh supply of oxygen.

The work of the pump on the left side of the heart is to receive the blood which has just been purified by passage through the lung capillaries, and to force it through the great artery (called the aorta), which branches to supply the capillaries of all the tissues of the body except the lungs.

It is evident that the left ventricle needs more strength than the right, for it has to force blood through the greater part of the body, while the right

ventricle drives blood through the lung capillaries only. It is interesting to find that this need has been met by the much thicker muscular walls of the left ventricle.

The rate of beating of the heart is controlled partly by nerves embedded in its own muscle, and partly by nerves which bring messages from outside. Some of these outside messages tend to make it beat more quickly, while others have precisely the opposite effect. Usually the two kinds of messages balance each other so that the heart beats at the rate which is required in ordinary circumstances.

When, however, something weakens those messages which tend to check the beat of the heart, the beat becomes more rapid, and may even cause palpitation. Active exercise usually makes the heart beat more quickly; in this case it causes a more abundant supply of blood to go to the active muscles, which, of course, are requiring more blood than usual.

Alcohol acts in somewhat the same way, and causes the heart to beat more quickly. But there is this interesting difference—that alcohol poisons the part of the nervous system which usually sends the restraining messages to the heart. In the first case, where exercise is being taken, the action is like the intelligent use of a brake by the guard of a train travelling over a railway line which is alternately up-hill and down-hill. In the second case, with alcohol, the result is as if the guard had gone to sleep: the brake is not used either down-hill or up-hill.

When at times of severe illness there is some danger that the heart may stop beating altogether, alcohol

may prove of the highest value when administered by a medical man, who may use it to "take off the brake." But at ordinary times the use of alcohol for this purpose is plainly absurd. Nor is this the only action of alcohol on the heart. Taken regularly, it has a tendency to cause fat to take the place of some of the muscle of the heart, a change which, of course, makes sound health impossible.

The action of strong tea or coffee on the heart is also to "take off the brake" and make the beat more rapid. Tobacco often makes the heart act irregularly, so that it cannot be relied upon to alter its rate of beating in the manner which is best in the circumstances. This is especially the result of smoking in people who have not finished growing. It has also been proved that smoking actually interferes with the building up of tissue during growth.

It should be remembered, then, that although no serious harm may be caused to the health of an adult man by smoking in moderation, tobacco has always a bad effect upon growing boys, and, if indulged in regularly, leads to stunted growth and a weak heart, besides injuring the brain-power.

LESSON XXVIII

ARTERIES AND VEINS

THERE are certain well-marked differences between arteries and veins with which everyone ought to be

familiar. One we have already learnt; we know that in an artery the blood is flowing away from the heart, while in a vein the blood is flowing towards the heart.

Another difference is that the blood flows through an artery in waves, which can be felt, one after another, by the finger at any place where an artery lies close under the skin. These throbs or waves form what is called the pulse.

Each pulse begins at the heart, at the moment when the contents of the left ventricle are suddenly forced into the aorta. The aorta is already full, so that the blood already in it, and in its branches, is moved on a little. In less than a second another portion of blood is forced into the full aorta, and again the blood in it and the smaller arteries is pushed a little further along.

Now, if the walls of the arteries were made of materials which would not stretch, the pulse would occur all over the body at the exact moment when the left ventricle emptied itself into the full aorta, because to make room for the new blood an equal amount would have to move on.

The walls of the arteries, however, are elastic, so that the room required for the new blood is obtained by the stretching of the aorta. And when the stretched aorta-base comes back to its former size, the artery stretches in the same way a little further away, then a little further away still, and so on; so that the jerky motion of the blood is, as it were, eased, and the flow made smoother.

In spite of this, with a healthy heart, the time between two beats of the pulse is always the same as the time between the corresponding two beats of

the heart, so that by "counting the pulse" we learn the rate of beating of the heart. A rapid pulse means a rapid heart-beat; a slow pulse means a slow beat.

On the other hand, there is very little elastic tissue in the walls of the veins, so that these vessels are unable to alter in width in the manner of arteries. This difference, however, is not the only reason why there is no pulse in the veins. The pulse disappears entirely in the smaller arteries, partly as a result of their elasticity, but chiefly because the blood is distributed among so very many of them that each receives no appreciable impulse.

Although the smallest arteries are unaffected by the pulse, they change in width very readily at the bidding of messages brought to them along certain nerves. When they become wider, of course, more blood flows through them to the capillaries, which they supply, and as a result the particular part of the body in which they lie is more active. We have already learnt how this affects the amount of sweat given off by the skin, and the blood supply to other organs is regulated in the same way.

FIG. 54.—A vein cut open to show the valves inside. The arrows show the direction in which the blood flows. (Larger than real size.)

Most of the veins possess, at intervals, valves of the kind shown in Fig. 54. They allow blood to flow easily towards the heart, but stretch across the vein and block the passage like floodgates if the blood begins to move in the opposite direction. It is clear

that pressure from surrounding organs, such as muscles, will help to move on the blood in a vein, so that many exercises assist the circulation in this, as in other ways.

There are other differences between veins and arteries, in addition to those mentioned hitherto. The fact that the walls of arteries are thick, containing a good deal of muscular as well as elastic tissue, while the walls of veins are much thinner, makes it easy to distinguish between the two kinds of blood-vessel in a piece of meat. An empty artery keeps its usual shape, and if it is cut across, the cut end remains open and looks like that of a thick-walled tube. An empty vein, on the other hand, collapses and becomes flat, as an empty canvas hose-pipe collapses and becomes flat.

If we leave out of consideration the vessels carrying blood to and from the lungs, we can distinguish between an artery and a vein by the kind of blood they contain. The blood in any artery contains an abundance of oxygen because it has not passed through any capillaries since it left those of the lungs. The blood in a vein, however, contains an abundance of carbon dioxide, but very little oxygen; for since it was last in the capillaries of the lungs, it has passed through the capillaries of tissues which have taken its available oxygen.

It so happens that the amount of oxygen in blood makes a considerable difference to its colour. Blood containing an abundance of oxygen is bright red in colour, while that containing but little oxygen is of a dull purple.

This important fact, together with others previously mentioned in this lesson, sometimes gives such valuable information of the nature of a wound that a knowledge of it may be the means of saving life. If the blood from a wound pours out in a steady stream of a dark purple colour, it is clear that a vein has been cut; and since the blood in a vein is flowing towards the heart, the way to stop the bleeding is to tie a bandage tightly —or otherwise to compress the vessel—on that side of the wound which is further from the heart.

But if the blood is issuing in jerks, and is bright red in colour, it must be coming from an artery; that is, the flow is from the heart, and the pressure should be applied on that side of the wound which is nearer the heart.

Further information on the best methods of stopping bleeding will be given in Lesson XXXIII. (page 172), but it will be understood better if the work of the present lesson has been mastered first.

LESSON XXIX

THE NERVOUS SYSTEM AND ITS USES

The activities of all parts of the body are regulated by what is called the nervous system. This consists of the spinal cord, the brain, and the nerves connected with them. In the spinal cord and the brain are certain very remarkable cells, called nerve cells, which are able to communicate with each other, as well as

with the sense organs, muscles, glands, and other tissues, by means of fine threads called nerve fibres.

It may simplify our ideas of these things to think of them as the telegraph system of a country. The country is the human body, the telegraph wires are the nerve fibres, and the electric batteries are the nerve cells. We shall also picture to ourselves the batteries as being nearly all collected in certain definite parts of the country—the spinal cord and the brain, which are together referred to as the central nervous system.

Further, we can suppose the organs of touch, sight, hearing, smell, and taste to be so many sets of telegraph instruments at certain offices along the frontier of the country, receiving and transmitting information concerning foreign affairs.

Although this comparison is very rough, and far from being true in all its details, it may be carried a little further. For example, a nerve fibre of the body can transmit messages in one direction only, being in that respect different from a telegraph wire. But, on the other hand, it is interesting to find that, on what may be called main lines, many nerve fibres are bound up together to form one nerve (Fig. 55), just as many telegraph wires may be bound up together to form one cable. And also, the nerve fibres in use are kept from touching each other—and their messages therefore kept from going astray—by sheaths of a fatty substance, just as electric wires are prevented from losing their currents by sheaths of indiarubber or silk.

Having gained some idea of the nature of the machinery of the nervous system, we must now learn a little of the way it works. Let us begin by con-

sidering the behaviour of a baby when its foot is tickled. At once the baby contracts certain muscles of its leg, and draws the foot away. It is natural to suppose that the action is due to a message sent along nerves from the tickled part to the muscle. This is not the case, however, for there are no nerves directly connecting the muscles with the skin.

FIG. 55.—Sketch of thin slice across one nerve, magnified. This nerve consists of seven nerve-bundles, which are shown. In two of the bundles the cut ends of a few of the nerve fibres are drawn. The fibres of the other five bundles are not represented.

The truth is, that a message has been sent from the tickled skin to the spinal cord, and, in response, another message from the spinal cord to the contracting muscle, the two messages being transmitted along entirely different fibres.

Fibres transmitting messages from a sense organ to the central nervous system are called sensory fibres; those carrying messages from the central nervous system to muscles or other tissues which are thereby made active, are called motor fibres. A nerve usually contains both kinds of fibres lying side by side, though a few nerves consist of sensory fibres only, and a few others consist of motor fibres only.

We have not finished with the baby, however. Most people would probably say that he drew away his foot purposely to avoid the tickling, because he disliked the sensation. Now, this might be true in some cases. All healthy persons, except very young babies, would

probably draw the foot away when they felt the tickling; and if we were sure the baby really felt the tickling we might be satisfied with this explanation.

But curiously enough, a sleeping person whose foot was tickled would also draw it away, and if asked about the matter afterwards he would admit that he felt nothing of the tickling. And also, people whose spinal cords have been so injured that they have lost all power of sensation in their legs and feet have been found to behave in just the same way. Finally, there is reason to believe that new-born babies cannot feel what is going on in their limbs; because the nerve fibres connecting the spinal cord with that part of the brain which feels have not yet got their fatty sheaths, and therefore cannot carry messages properly.

Very soon, however, these fibres become complete, and the baby feels what is going on in his limbs. Then when his feet are tickled he will not only draw them away, but will also laugh, showing that he feels the tickling. Sensations are felt by the nerve cells of the brain; feeling is impossible unless there is a complete line of nerve fibres between the sense organ and the brain.

It seems quite clear, therefore, that movements may be due to unfelt causes. Such actions are called reflex actions. Just as they are not the result of feeling, so they are not the result of intention, or will. In other words, such movements are made in obedience to commands from the spinal cord, not to commands from the brain. It is plainly an advantage that the simplest actions, which are necessary very often, or must be

performed regularly, shall not require the special attention of the brain.

At the top of the neck, where the spinal cord widens out to join the brain, is a part of the central nervous system called the spinal bulb. This is concerned with certain specially important reflex actions—the sending of regular messages to the heart muscles, and to the

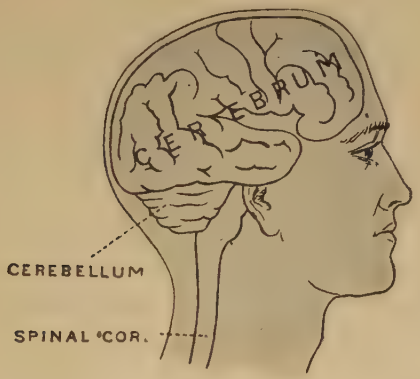


Fig. 56.—The brain and the adjoining part of the spinal cord.

muscles which bring about the movements of respiration. It is a very interesting fact that if the blood supplying the spinal bulb contains more carbon dioxide than usual, the movements of respiration are made more rapidly; and consequently the carbon dioxide is more quickly got rid of and replaced by fresh oxygen.

The part of the brain which is nearest the spinal bulb is called the cerebellum (Fig. 56). Its work is to regulate the balancing of the body, by letting the muscles know at what exact moments, and exactly how

much, they must contract. This is evidently a more delicate function than the work of the spinal cord, for it requires a certain amount of consciousness, and we have seen that consciousness is unnecessary for reflex action.

The highest of all the powers of the nervous system reside in the rest of the brain, called the cerebrum. It is here that the news from sense organs gives rise to feeling and thought. From it orders are sent out to move this or that part of the body, if consideration of the news received has shown that movement is necessary. Such decisions may or may not agree with the unintelligent impulses of the spinal cord. Also the cerebrum, having this control over most of the other parts of the nervous system can, as it were, educate them to perform certain regular actions with less and less supervision. At length these actions are carried out with scarcely any attention from the brain, and become what we call habits.

Set free in this way from the details of reflex action and habit, the cerebrum is able to pay more attention to other matters. It compares the items of news received from the various sense organs with one another and with its memories of past experiences, and then it decides on the wisest course of action. Having this wider outlook it becomes aware that in certain circumstances the impulses of reflex action or habit are foolish or wrong, and in such cases it is able to set aside these impulses, and in spite of them to do what it knows to be right.

The powers of the nervous system are the most important powers we have, for the successful working

of all other parts of the body depends on them. We need above all, therefore, to avoid injury to the sense organs and the brain.

The brain is most liable to injury by the presence of poisons in the blood, and the action of poisons is naturally most severe upon the most sensitive part of the brain. This, as might have been expected, is the cerebrum. Alcohol and certain other poisons, known as narcotics, have the effect of making the cerebrum less sensitive, especially to pain. Opium, cocaine, chloral hydrate and chloroform are well-known examples of narcotics.

Such poisons are naturally most dangerous, because the warnings of pain are among our greatest blessings. If for no other reason, therefore, it would be very foolish for healthy people to take narcotics, and sacrifice so much useful knowledge of the dangers they might avoid. On the other hand, narcotics are often of the greatest value, when administered by medical men, for the relief of sufferers from the pain of disease or surgical operations.

The effect of narcotic poisons, however, does not stop with the deadening of pain. The disturbance of the nervous system naturally interferes with the healthy action of all parts of the body, and if persisted in leads to the ruin of body and mind.

LESSON XXX

SOCIETY AS AN ORGANISM

It has been remarked by several persons that there are a great many points of resemblance between the various organs of an animal or of a plant and the groups of men and women engaged in various occupations, which compose what is called human society.

Now that we have completed this brief survey of the human body, its structure and its functions, we are in a position to understand this interesting comparison, and we shall find that it explains the nature of many of our responsibilities towards others, and of many of the privileges which we owe to others.

In a former lesson we found it useful to regard each cell of a plant or animal as a living brick in some complicated building. We shall now see how far it can be compared to a single human being living his life among his fellow-men.

It is clear, once the idea has been grasped, that the cells which compose any tissue are, as it were, workmen of one trade. Thus the cells of muscular tissue are labourers whose business it is to move things from one place to another. The cells in bones, cartilage, and teeth are builders; some of them construct peculiar forms of cranes and other ingenious combinations of levers (the bones of the limbs are examples). Other builder-cells are occupied in making protective coverings for the more delicate workmen of certain other trades,

while others still are responsible for the mill used in crushing and grinding food for all.

The cells of the digestive glands are the cooks of the colony, getting ready, for rapid distribution to all parts, the food which was caught by some muscle-persons, and crushed by others.

FIG. 57.—Some typical animal cells, as seen under the microscope.

Still another set of cells is engaged in the carrying trade of the country (which is all done along rivers and canals), bearing digested food and oxygen rapidly to all the workers, and relieving them of the rubbish and refuse which have accumulated during their labours. Surplus food is carried to suitable storehouses, and there packed in the most convenient form for prompt distribution when required. Stationed at certain places along the waterways are those who work the pumps and lock-gates by which the current is regulated and directed. Patrolling the stream are the policemen-cells which we know as white corpuscles, ready at a

moment's notice to attack any enemies which may have landed on the banks.

We have learnt, too, how, on every part of the frontier, are stationed watchful observers with telegraph instruments, sending at every moment information to the members of the government—the cells of the central nervous system; how these in their turn consider the

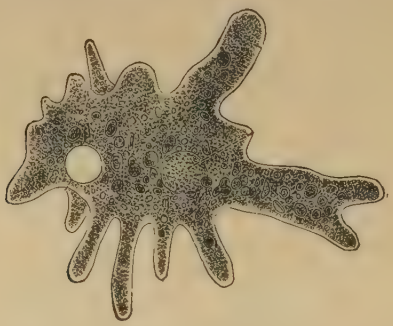


FIG. 58.—*Amoeba*, as seen through a microscope magnifying 400 times in every direction.

news, and telegraph orders hither and thither according to its nature and importance.

This short comparison of the human body to a country is plainly very incomplete. It would be possible to go into much more detail and show that the resemblance is even closer than appears in the account given above. But it becomes even more instructive when we study it side by side with the life-histories of certain very simple animals.

In the mud of nearly every pond and ditch there live large numbers of tiny creatures called amoebae. An amoeba is usually about one-threehundredth of an inch across, so that it cannot be studied except with

the help of a good microscope. An amoeba is shown in Fig. 58, as it appears when magnified 400 times.

For our present purpose, the most interesting fact about this little animal is that it consists of one cell only, whereas we ourselves, and all the commonly known animals, are made up of millions of cells living together in a great colony and each performing one special duty. Division of labour is the secret of success, and naturally a healthy cell which has one duty only is able to carry out that duty very perfectly.

Amoeba, on the other hand, is compelled to do everything for itself. Being a single cell, it has no limbs, no bones, no blood, no mouth, no alimentary canal, no lungs, no nervous system, and no organs of sight, smell, taste, or hearing. Yet it must move about, catch and devour its food, breathe and excrete —for it is alive; and life, as we know, is the sum of such activities.

Amoeba is like Robinson Crusoe alone on his island. There are other amoebae close by, but they do not join together, one to do one kind of work, another to do another kind, and so on, so that all shall benefit by their special skill. Each amoeba continues to live its lonely life.

We are told that Robinson Crusoe made all his own clothes and shoes—even including an umbrella—built his own house and boat, caught and cooked his own food. We admit that he was a very clever man, but we are quite sure that his umbrella, his clothes and shoes, his house and his boat, were not nearly so perfect as those produced by men whose special work it is to make such things. In the same way the

functions of an amoeba are carried out much less perfectly than those of a healthy animal or plant which consists of a multitude of cells, each concerned with doing one thing well.

If we admit that a man is more admirable than an amoeba we must also admit that society is better than a life of solitude; and we learn from our knowledge of the human body—regarded in this way—what are the conditions of healthy and happy human society. They clearly depend upon the faithful performance, by every member of it, of the duties for which he is best fitted; and it is clear, also, that the whole of society will suffer if any person fail to perform these duties to the best of his ability.

LESSON XXXI

THE RESPONSIBILITY OF THE INDIVIDUAL

Our study of the human body and of the means of keeping it in health has led naturally to the larger idea that the care of our own persons is only one of a number of duties we are bound in honour to attend to. We are now sure that in some measure the good of the whole race depends upon our actions. Our part in this great work may be small or it may be large, but in either case we recognise that our responsibility is a real one and that it should call out the best of which we are capable.

One fact which these lessons have repeatedly made

clear is that our health affects the health of all who associate with us. Just as no one can have dirty habits without making it more difficult for others to keep clean, so no one can have an unhealthy body without making it more difficult for others to remain healthy. In a very real sense, disease is the dirt of human society.

The duty of keeping healthy and of doing everything possible to help others to keep healthy is, then, of very great importance, but it is only the starting point of our duties to our fellows. Regarding ourselves as cells in a tissue, we have to make ourselves fit for our work in life and afterwards to do that work with unswerving loyalty.

In childhood and youth we prepare for this work by education. This education is by no means confined to what are called lessons; it includes games and gymnastics, that it may bring about the cultivation to the highest possible pitch of perfection of every faculty, physical as well as mental, which will be of use in our adult life. It includes also the training of the social conscience, which makes us regard our duties to others as the highest of all duties.

We learn to be anxious to help rather than to be helped, and therefore realise the value of a reasonable prudence and thrift. These good qualities, however, must not be allowed to sink into excess. Excessive prudence becomes cowardice, and excessive thrift leads to miserliness, both of which are harmful to the community.

The welfare of society depends on an agreement that all its members shall obey certain laws. This

agreement is not entered into as a formal promise by every person, but it is none the less real and binding on everyone who lives with his fellow-men. Such laws are meant, above all, to safeguard the lives and property of every member of society, and therefore no crimes are held in so much horror as those of murder and theft.

But it is clear that any offence which makes it impossible for others to live healthily is of the nature of murder to some extent; and that any action which makes the rights of others less secure is to some extent of the nature of theft. It has therefore come about that all civilised nations have laws for the punishment of other offences besides the crimes of murder and theft.

Yet a person who realises the importance of his part in society will not be content merely to avoid the breaking of laws. He will avoid offending against the spirit of a law, because he understands the reasons for which laws were made. He will feel that truthfulness and courtesy, for example, are of great importance, and are necessary to the making of a good citizen, although they cannot be enforced by laws.

An overweening sense of self-importance is called conceit, and naturally arouses the dislike of those who see it in others. Yet it is possible to go to the other extreme and become so painfully shy that we do not make the best of ourselves. We must try to keep the balance between the two: to consider always the rights and feelings of others, but to keep also a due self-respect. Such a balance preserves us both from selfishness and from committing many unworthy or

degrading acts. We must remember that our own value is measured by our present or future use to our race, and that this value is a real one.

To bear this in mind gives us a feeling of self-respect which is in every way to be encouraged. It makes us take a pride in preserving and increasing our value to the race by all means in our power.

One powerful motive of this kind is found in the reflection that the children of this generation will be the parents of the next; and that the health of, at least, the next generation will depend upon the qualities of the minds and bodies which are at present in our own care. To keep these minds and bodies pure as we grow to manhood and womanhood is one of the most sacred of our duties. Rules of bodily health alone are not enough for this; we need also to keep our minds clean and healthy, and for this we must be as careful in our choice of friends and books as in the selection of foods and beverages.

The more we think of the duties which are laid upon us as a consequence of our membership of society, the more we realise that they are all included in the idea of loyalty and what is called "playing the game." In our games we learn to scorn above all things cheating, and shirking the duties of the post which the captain of our side has given us. We learn to check rash impulses, and to judge every action by one test—the effect it is likely to have on the honour and success of our side.

Surely we shall endeavour to show ourselves no less trustworthy in playing our parts in the sternest and noblest of all games—the struggle of the human race

towards perfection. Our enemies are disease, ignorance, and selfishness. We know now the chief rules which make for success:

> "Self-reverence, self-knowledge, self-control,
> These three alone lead life to sovereign power."

PART II

FIRST AID AND HOME NURSING

LESSON XXXII

THE PRINCIPLES OF FIRST AID IN ACCIDENTS, INJURIES, AND ILLNESS

SUDDEN accident or injury may happen to anyone at any time, and it may make all the difference to the sufferer whether the persons who are present at the time do, or do not, know what is the best thing to be done for him. Everyone wishes to help a person who has been hurt, and to relieve his pain, if possible. But there is only one right way of doing this in each case.

If the spectator did not know this right way, it would be unwise and foolish, as well as unkind, to try to do anything ignorantly; because this, more likely than not, might make matters worse for the sufferer—perhaps very much worse. Yet there are some useful things which even the ignorant person can do, if only he does not get excited or frightened, but keeps cool and tries to remember what he would wish one of his playfellows or companions to do, if he were hurt himself.

For instance, he can get someone to send for the doctor, or for other help; or he can go himself, if there

be another person whom he can leave with the sufferer to explain how the accident arose, should help come from another quarter while he is absent. When going or sending for the doctor or other help, always try to remember that the messenger should be able to state, as clearly and briefly as possible, who has been hurt—whether it is a man, woman, or child—and how the injury happened. Such information may enable the doctor to bring with him something which will be wanted at once, and thus avoid delay in properly treating the injury.

It is not surprising that a person who sees a serious accident, for the first time in his life perhaps, should feel frightened. But he will not help the sufferer by giving way to this feeling of alarm. If you, for instance, were to see one of your friends or playfellows lying unconscious on the ground after a bad fall, and bleeding from a nasty cut in his head, you might feel that you wanted to cry and scream, but you would not help him by doing this; you would, in fact, prevent yourself from being able to help him.

It may be true that he is bleeding; but the blood which you see will not hurt you. You have learned something about it, and you know that it will be better for him if the bleeding can be stopped. Perhaps, if you retain your presence of mind, you will remember some of the ways in which this can be done; and if you succeed in doing this, you will be glad that you were brave and unselfish enough to think more of how you could help your friend than of how bad his accident made you feel.

It may be true also that he is stunned and unconscious; but you have learned that this means that part of his brain is, as it were, asleep, and that therefore he does not feel any pain. You will be glad to remember this, especially as his unconsciousness of pain may permit of things being done for him—necessary things, such as sewing the edges of a wound together—without his feeling the discomfort which this would cause him if all his senses were alert.

In all such cases, then, try not to be selfish. Try to remember that the really important thing is—not what you feel, but what you can do. Remember, also, that even if you can do nothing but watch and wait until somebody comes by whom you can ask for help, you will still be of great use if you have kept your presence of mind so that you are able to speak plainly and quietly, and to tell exactly how the accident happened, and to answer clearly such questions as may be asked of you. Then your parents or your teacher or the doctor will be able to say: "You have done very well; no doubt you felt frightened, but you did not let this make you behave foolishly; you were brave and quiet; you did all that you could; and you have been a real help to us all."

You cannot expect to learn all that a doctor or a nurse would know and be able to do for a person suffering from sudden illness or serious accident. But you may learn some simple things which are very useful in such cases; and if you think about them, and try to understand the reasons for them, you will not find them at all difficult to remember. And if you feel that you do know of something useful which

you can do, you will find that you are not nearly so frightened, because you will not feel so useless.

Accidents and Injuries to the Head.—A severe blow on the head may break the bones of the skull, and even injure the brain beneath them. In any case the brain will be seriously shaken, and perhaps bruised, so that the patient loses consciousness—is stunned, as we say—for some time. As the brain recovers, the unconsciousness passes off, and the sufferer may be able to get up and walk, and soon feel as if he were quite well again. But, however well he may feel, the delicate substance of the brain needs some time to recover its power, and it is not likely to do this completely unless it is allowed to rest for a while.

Therefore, however slight the injury may seem to have been, and however quickly the patient may have come to his senses again, it is a good rule that he should be put to bed as soon as possible after the accident, and be kept there quite quiet, with as little talking as possible and no reading, for two or three days. In this way he may hope to escape the bad headaches which sometimes follow after even slight injuries of this kind, and may last for a very long time. This is, of course, most important in the case of children and young people, whose brains are not yet fully developed, and are the more liable to be seriously damaged by comparatively slight injury.

Bleeding from a wound of the scalp may be staunched by firmly tying a clean folded handkerchief round the head over the bleeding spot. If clean water is at hand, this should be used for gently washing away dirt, etc., before the bandage is applied. Water

as hot as can be *comfortably* borne should be used for this, if it is easily obtainable. If blood is seen running out of the ear after a heavy blow or fall on the head, the case is usually very serious indeed; no time should be lost in calling in the doctor or in getting the sufferer to the hospital; and great care should be exercised when lifting and moving him.

Sometimes a person, after suffering an injury to his head, recovers consciousness quickly and completely, and may be able to walk or drive home; but, after a time, begins to grow stupid and drowsy, and then soon becomes again unconscious. This indicates that a blood-vessel beneath the skull has been wounded, and that the accumulation of escaping blood is causing pressure on the brain itself. No time should be lost in sending for the doctor in these circumstances; and meanwhile the sufferer should be laid in a comfortable position on the bed or sofa, with the head *slightly* raised.

Whenever a person becomes unconscious, all tight clothing about the neck, chest, and waist should be loosened; and he should be placed, lying down, in that position (generally rather on one side) in which he seems to breathe most easily. If a person has lost consciousness after a fall or blow, do not attempt to rouse him by shaking him or handling him violently in any way. The accident may have caused damage to some other part of the body besides the brain, and needless movement might easily make this worse, especially as the injured person, being unconscious, cannot warn you that you are causing him pain. In any case, such attempts to rouse him can do no good.

For similar reasons, a person found to be unconscious as the result of an accident should be handled, moved, and lifted with the utmost gentleness and smoothness; and while he is being lifted it should be the special care of one person to keep the head and neck supported in an easy, natural position. When a person has been stunned, he is often violently sick just before he comes to his senses again. Such vomiting, therefore, may be taken as a good sign rather than a bad one, indicating an early return to consciousness. But, since he is seldom fully conscious when the sickness begins, there is some danger lest the vomited matter should be drawn into the windpipe and cause suffocation. Hence, if there be any sign of vomiting, the sufferer should be at once gently turned on to his side, so that the vomited matter may escape easily and completely from his mouth. An unconscious person should never he left alone and unwatched, however quiet he may seem to be.

The Eyes.—Any injury to the eye is a serious matter, and should be attended to by a doctor as soon as possible. The eye may be gently cleansed by carefully pouring a gentle stream of warm water over it, or by squeezing water on to it from a clean, full sponge. If there be bleeding, cold water may be used. A small pad of clean linen may be placed over any bleeding cut on the brow and kept in place by a folded handkerchief tied round the head so as to cover *both* eyes. An inflamed or injured eye cannot be effectively rested by a bandage or shade made to cover that eye only. The shade must cover both eyes. For the two eyes always try to work together; and the action of light

upon the uncovered eye results in the covered eye endeavouring to work too, and so prevents its getting the rest it needs.

When an eye becomes red and inflamed it may be bathed (through the closed lids) with water as hot as can be borne (not with *milk*), and protected by an eye shade which shades *both* eyes; it should always be seen by a doctor as soon as possible.

The Ears.—Severe bruises of the external ear—the "ear flap"—(such as are sometimes sustained in football) often give rise to a good deal of swelling. A pad and bandage kept wet with quite cold water may be applied at once. But such cases should be seen by a doctor; because, if the swelling be left to itself and not properly attended to, deformity and distortion of the ear are apt to follow.

Pain in or behind the ear, or discharge from the ear, must never be neglected. Either may be due to serious and deep-seated disease, liable not only to produce permanent deafness, but capable of giving rise to disease of the brain, unless skilfully treated from the beginning.

Loss of hearing in one or both ears should be attended to promptly. It may be due to an accumulation of wax in the ears, or to causes much more serious and important which require special treatment. And we must not forget that wax in the ear may be present in addition to some other cause of deafness.

Babies and quite little children sometimes suffer from pain in the ears which may be overlooked until after the child has become dangerously ill. If an

infant cries often, though but for a short while at a time perhaps, and seems to be restless and in pain, without any of the usual causes of discomfort being discovered, the doctor should be asked to see it; and especially if the pain seems to be brought on or increased when one or other ear is touched or pressed upon, as while the child is being washed and dressed.

The Nose.—A fall or a violent blow on the nose may cause breakage of the bones which maintain its shape; such an accident is generally accompanied with free bleeding. After the wound has been cleansed by a gentle stream of warm water, a folded piece of clean linen may be placed over it, and kept wetted with cold water, until the sufferer is seen by the doctor. A pad of linen wet with cold water may be bandaged over the wound as firmly as can be borne, if there be much outward bleeding. The sufferer should recline on a bed or couch, with his head raised, his arms and hands being placed above his head and resting against the wall, the head of the bed, or the back of the sofa.

LESSON XXXIII

WOUNDS, CUTS, BRUISES, AND SPRAINS

THERE is one point always to be remembered in the treatment of wounds and injuries of all kinds. One of the first results of the injury is an increased flow of blood to the damaged part; and sometimes, as

is the case with a bruise, for example, an increased difficulty in the blood flowing away from it. Sometimes, as in the case of a severe cut, the blood may escape from the part as fast as it reaches it. But, if the bleeding be stopped, there will then be the same tendency for blood to accumulate at the place of injury. This excessive amount of blood in the tissues not only causes swelling, resulting in pressure on the exposed nerve-ends, and therefore pain, but also hampers speedy healing. Hence this condition should be prevented whenever possible.

We know that blood, like water or any other liquid, flows more readily downhill than along the level; and that it has to be in some way forced, as by pumping, to make it flow uphill. We can therefore easily understand that if an injured part be held up, blood will flow into it less speedily along the arteries from the heart; while, at the same time, blood will flow more readily away from it, through the veins, back to the heart: in other words, it will be less readily filled and more readily emptied of any excess of blood. We may notice, for instance, that if the arm is kept outstretched above the head for a few minutes, the hand becomes pale; and that if the hands are allowed to hang down, they soon become more swollen and red.

These are the reasons for the rule that **any injured part should be placed as soon as possible in a raised position**—at least as high as the rest of the body, and even a little higher, if this can be done with comfort. After the injured part has thus been drained of its excess of blood, moderately firm and even bandaging will help to support the damaged tissues

and to prevent their swelling and throbbing. If the injury be at all a serious one, the injured person should himself be made to lie down flat, because, when one is lying down, the heart beats more slowly than when one is standing or even sitting up. There is one other rule worth remembering:—that position of the damaged part which is most comfortable to the injured person, is, generally speaking, the best for it and for him.

Some wounds, such as those due to a blow from a heavy stick or stone, gunshot wounds, and those caused by the crushing effect of a heavy wheel or other machinery—or, again, by a fall from a height on to a hard surface—may be looked on as a combination of cutting or stabbing and bruising; and they will often call for immediate steps to staunch the bleeding from cut or broken blood-vessels. (For these steps see the directions given under CUTS, p. 171.)

But it must not be forgotten that, in such cases, also, the wound visible on the surface of the body—the external wound—may be only a part, perhaps the least serious part, of the mischief. Bones may be broken, and internal organs pierced or bruised by the violence of the injury. Therefore, in every case of this kind, care must be taken to move the sufferer no more than is necessary, and as gently as possible, and to keep him well covered up and warm; for every severe accident is attended by more or less "shock," so that the injured person is apt to become pale and cold and faint.

If the wounded part be covered by clothing, which cannot be easily lifted aside or rolled out of the

way, this must be removed before the wound can be properly attended to. And (unless we are *sure* that the wound is only quite slight and superficial), the clothing must not be taken off in the usual way, as this would involve more or less serious movement and disturbance of the injured part, without our being able to see what mischief we might thus be doing. The stitching of the seam—*e.g.* the outside seam of a coat sleeve or of a trouser-leg—must be cut with knife or scissors for its whole length from top to bottom, so that the clothing may be drawn away from the injured limb without disturbing the latter. By cutting along a few of the seams on the damaged side, and then carefully drawing each garment off the body in the usual way *on the sound side*, any person who has been gravely injured may be completely undressed, if necessary, as he lies in bed, with the least risk of increasing the injury or of causing pain. Later, by again sewing up the seams, each garment will be made as good as before.

Similarly, a boot may be removed from an injured foot after slitting the back seam and withdrawing the laces.

Before any open wound is bound up, it should be cleansed as thoroughly as possible, and particularly if any road-dirt or soil or broken glass have got into it. This is best done by letting a gentle stream of clean warm water flow over it, so as to wash away the dirt—not by rubbing or dabbing the wound. If the bleeding is at all free, the water used for cleansing should be as hot as can be borne without pain.

Cuts and Stabs.—These may be of all degrees of

severity. If bleeding is at all severe the doctor should be sent for at once. We should try (1) to cleanse the wound; (2) to check bleeding if necessary; (3) to remove clots of coagulated blood which are separating the cut surfaces; (4) to bring the cut surfaces closely and neatly together, and keep them so by a bandage firmly and evenly applied.

Among **means of checking bleeding** may be mentioned cold water; hot water; elevation of the injured part; pressure by the fingers, or by a pad and bandage over the wound; pressure by a finger or improvised tourniquet on the artery above the wound, or on the vein below the wound.

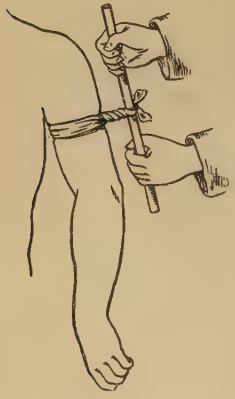


FIG. 59.—How to apply a knotted handkerchief as a tourniquet above a wound in an artery.

A **tourniquet** is an instrument which can be used for applying pressure over a blood-vessel so as to stop the flow of blood through it. In its simplest form it consists of a band of webbing or other stout material, or of indiarubber, which is made to encircle the limb, and is then drawn or twisted tight until the flow of blood in the underlying vessels is stopped.

Thus a twisted handkerchief can be knotted loosely round an arm above a deep cut, for example, and then tightened by passing a stick through the loop formed by the handkerchief, and twisting the stick until the handkerchief is sufficiently tightened (as shown by

the stoppage of bleeding from the wound below). The handkerchief is then kept from untwisting by tying one end of the stick to the limb, as shown in Fig. 60 at A, where an improvised tourniquet has been applied to stop bleeding from a wound in the foot.

Deep cuts or punctured **wounds of the palm** may cause severe bleeding. Obtain a *firm* pad (such as a knot in a handkerchief, a cork, a round stone, a piece of wood, or a small apple or potato, wrapped in clean linen and placed over the wound); bend the fingers tightly over this, bend the hand on the wrist as far as possible, and bandage firmly in this position; bend the forearm at the elbow as far as possible, and bandage to the upper arm. In bleeding from a **ruptured varicose vein in the leg**—not rare in elderly people—elevate the leg, apply a pad over the bleeding spot, and bandage firmly.

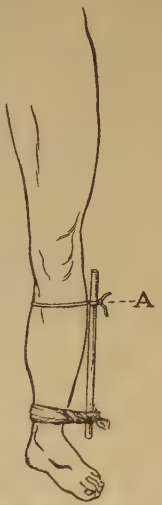


FIG. 60.—Fixing a tourniquet in position to stop arterial bleeding from a wound in the foot.

Deep cuts or stabs of the neck, chest, or abdomen are very serious accidents, and no time should be lost in sending for the doctor. The patient must be made to lie down, must abstain from all talking, and must be kept as quiet as possible. If the wound be in **the neck**, we may try to restrain the bleeding by thrusting the tips of the thumb and forefinger deeply into the skin and pinching the lips of the wound together; by using the finger and thumb of the other hand to keep

the first finger and thumb pressed together, such pressure may be kept up for some time with much less fatigue.

If the wound be in **the chest**, the injured person should lie on the wounded side, and try to breathe as quietly as possible.

If **the abdomen** have been wounded, the person should lie on his back. No food, except occasional small sips of cold water, or small pieces of ice, to allay thirst, should be given until the doctor comes.

Bruises.—If the bruise be a large one and swelling rapidly, the part should be raised, its surface should be quickly rinsed with a stream of clean water as hot as can be borne—if this is at hand—dried by gentle dabbing with a soft cloth, and then covered with a layer of clean cotton wool or wadding to a thickness of at least two or three inches, which should be kept in place by a bandage evenly applied with as much firm pressure as can be borne without actual discomfort. At the end of twelve hours or so the wadding should be removed, and another thick layer of fresh wadding put on under a bandage in the same way.

If cotton wool or wadding be not obtainable, some soft elastic woollen material, such as a knitted shawl or a pair of thick stockings, may be folded loosely so as to form a pad of a suitable size, and bandaged on.

Care should be taken to protect a seriously bruised part from being again struck and further bruised until after it is quite healed.

Sprains.—Severe strains of the parts surrounding a joint are called sprains. They involve more or less

tearing of the ligaments of the joint, and sometimes injury to the tendons which run close to it as well.

We should not forget that when an ankle has been badly sprained, the tip of one or other of the long bones which help to form the joint may be broken away from the rest of the bone. What is sometimes thought to be a bad sprain of the wrist is apt to be complicated by fracture or other serious injury of one or both of the bones of the fore-arm at their lower ends.

If a sprain can be treated promptly, an excellent plan is to *keep* the joint immersed in water as hot as can be borne for several hours; for example, a sprained ankle is to be at once placed in a foot-bath half filled with comfortably hot water, to which hot water is added (in a small stream, gently stirring the while) until it cannot be borne any hotter, and the bath is nearly full. Then a cupful or so of water is to be taken out of the bath every few minutes, and an equal amount of very hot water gently added, so as to keep up the temperature of the bath for as many hours as possible. At the end of this time, the foot and leg should be taken out of the water, raised and quickly dried, covered with a *thick* layer of cotton wool or other soft and elastic material kept in place by a firmly applied bandage, and maintained in a raised position until the next morning, when the cotton wool and bandage should be renewed.

If this cannot be done, the injured part should be raised as high as is convenient—supported on the back of a chair or the head of a sofa for ten minutes, so that the excess of blood may drain away from it.

A *thick* layer of cotton wool or the like, under a firm, evenly applied bandage should then be applied to the joint; and this dressing should be renewed at the end of twelve hours.

A severe sprain is apt to leave the joint more or less weak for some time.

LESSON XXXIV

FRACTURES AND DISLOCATIONS

Fractures.—"Fracture" is another word for break, and has the same meaning; a "fractured bone" is a broken bone; and though you will not know how to "set a fracture," as it called—that is, how to put the broken pieces in the proper position again, and to keep them there so that they may grow together neatly joined—you should learn what may be done to prevent the damage of a broken bone from being made any worse than need be.

Signs of fracture: local pain, loss of power, mobility, distortion.—The bones, as you have learned, are surrounded by muscles and nerves and blood-vessels under a covering of skin. If the splintered ends of the broken bone are moved, there is a risk of nerves being wounded and blood-vessels torn; and, if the movement be violent, a sharp end of bone may even be forced through the skin and thus exposed to dirt which may make the wound unhealthy and even very dangerous to life. Hence the great importance of handling and lifting a broken limb with intelligence as

well as with care and gentleness : and the importance, too, of arranging some means of keeping the broken fragments fixed and steady while the sufferer is being lifted or otherwise moved.

To make this clearer, let us suppose a heavy stick

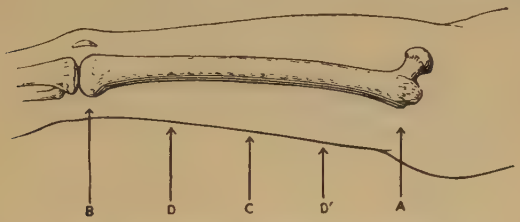


Fig. 61.—Diagram of a thigh bone, unbroken.

to be wrapped in some loose folds of thin paper. This model might represent the thigh bone, for instance, covered with its layers of muscles, and the great nerves and blood-vessels (arteries and veins) which spread amongst them, quite close to the bone in many

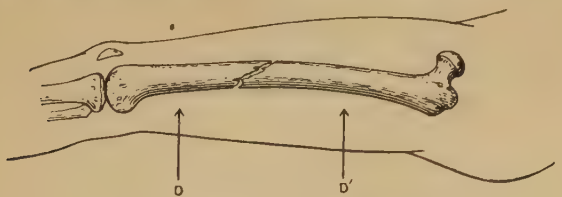


Fig. 62.—Diagram of a broken thigh bone.

places. Now, so long as the stick (or the thigh bone) is not broken, we can lift it quite safely, and without any risk of doing harm—and with one hand only—and it does not matter whether, in order to lift it, we apply our hand to one end (at A or B), to the middle (C), to any other point (as D or D′) (Fig. 61).

But suppose the stick were broken somewhere near the middle of its length about C (Fig. 62), and we were to lift one end, say A, or merely to support the limb at that point only, we know what would happen then. We should separate the broken ends at C (Fig. 63). And if we raised A roughly or high enough, we

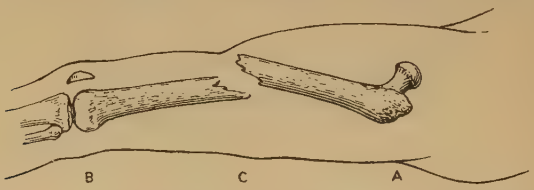


FIG. 63.—The fracture made worse by supports. The broken thigh supported at one point only A, and so allowing the weight of the leg to separate the fragments.

should very likely find the sharp splintered end of the fragment A tearing its way through the paper at C (Fig. 64). If we imagine A to be the hip joint and B the knee joint, we shall understand the serious

FIG. 64.—The fragments further displaced, so that the sharp end of the upper one has been forced through the skin.

mischief which might follow from handling a broken thigh bone in this way.

Again, if we tried to raise the broken stick by lifting it at C, we should again have something like the result shown in Fig. 64—the same kind of damage produced in a slightly different way.

But if we lifted the broken stick by grasping its two pieces firmly about the middle of their length (as at D and D′, Fig. 62) one in each hand, raising each hand steadily so as to keep the two pieces in their proper position to each other, we ought to be able to lift it without appreciably separating its

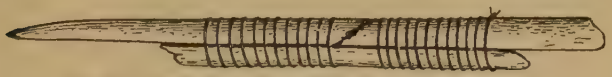


FIG. 65.—A broken spar "fished" by lashing its two parts to another shorter piece.

fragments or damaging their covering of thin paper.

But it would be better and safer (and in the case of a broken bone, much less painful) if we could fix something to the broken limb which would keep the

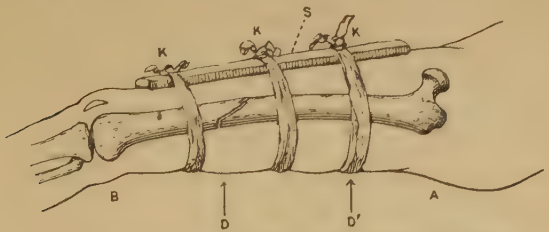


FIG. 66.—Splint applied and bandaged in position over broken thigh bone.

fragments from moving on one another, and this can almost always be done.

If a fisherman has a broken mast or spar which he wants to be able to use at once, he "fishes" it, as he would say; that is, first laying the broken pieces in their proper position, he places alongside them another piece of wood, the longer the better within reason, and

binds the two broken pieces to it, so as to keep them in place (Fig. 65). The surgeon does exactly the same kind of thing when he "splints" a broken limb. And if, over our broken stick A, B, with its paper covering, we place another piece of stick (S) (Fig. 66) as a splint, binding them firmly together on either side of the fracture with two handkerchiefs, there will be little risk of the two broken ends separating and doing harm if the fractured stick be moved with the firm, steady, and careful handling which should be always used when dealing with a broken bone.

But, even with the splint applied, if the limb has to be moved or lifted, this should always be done with *two* hands, grasping each of the broken parts firmly and steadily (as at D and D′).

So that **the first thing to be done** if a limb be broken, is to place it so that the two fragments lie as nearly as possible in the same straight line—so that it looks like the sound limb—and then to apply to it some firm support, of sufficient length, binding it to the limb above and below the seat of breakage so that it may act as a splint.

A **rough splint** may be improvised by using a walking stick or an umbrella, a cricket bat or a couple of cricket stumps, two or three stout sticks cut from the hedge, or even a piece of paling or board —padding the hollows with grass or rags or a soft cap; and it may be secured in place by means of handkerchiefs, belts or straps, etc. If a leg is broken, both legs should be fastened together by three or four bandages placed at intervals from the hip to the ankle—after first applying a splint to the injured

limb. The sound leg aids by acting as an additional splint to its injured fellow.

An ordinary flexible copy book makes a useful emergency splint for the fractured forearm of a child. It should be first rolled up tightly so as to make it take a natural curve, then rolled round the injured forearm with gentle firmness, and secured by knotting two or three handkerchiefs round it.

If there be any external wound, the clothing over it must be cut away, the wound cleaned by a gentle stream of warm boiled water, and the bleeding should be stopped; the wound should then be covered up from the air by a pad of some clean material, so as to exclude harmful germs, before the splint is applied.

If one or more **ribs have been broken**, there is pain and tenderness at the seat of injury, made worse by taking a deep breath, sneezing or coughing. If a round towel be obtainable, it should be rolled up closely, and then applied firmly like a bandage, round the whole chest, from the armpits downwards, so as to fix the chest wall, and fastened by half a dozen safety pins. When no towel is obtainable, a tolerable substitute may be found by removing the patient's own waistcoat, placing one or two other persons' waistcoats round the chest (without putting the arms through the arm-holes) and then replacing the sufferer's own waistcoat (not putting his arms through the arm-holes) and buttoning it over the other waistcoats (drawn tight) so as to embrace the chest in a closely fitting casing. Should an end of the broken rib have pierced the lung, bright coloured blood may be spit or coughed up. In such a case, the very greatest care

must be used in avoiding all movement of the patient which is not absolutely necessary: he should be kept lying down, in the position which he finds most comfortable, until seen by the doctor.

When **the collar bone is broken,** the sufferer should be laid on the ground, on his back, with a folded coat placed lengthwise beneath the upper part of his spine, so as to let the shoulder on the injured side fall back. The forearm on the damaged side should be laid across the chest. This position should be maintained until the doctor arrives. But if the patient must be sent home or to the hospital for treatment, a folded handkerchief should be carried over each shoulder and under the armpit and the ends of each tied together: another handkerchief, duster or belt should be passed through these two loops at the back, and drawn tight, so as to pull the shoulders well back, and tied. A firm pad about twice the size of the sufferer's fist (a rolled up waistcoat, for example) should be placed in the armpit on the injured side, and the upper arm on that side bound close to the chest, till the collar bone comes back to its natural shape (like that of its fellow on the other side). The wrist should then be slung to the breast of the shirt (so that the hand is higher than the elbow) and the elbow allowed to hang unsupported.

In every case of serious fracture, after cleansing any wound, stopping bleeding, and applying a splint, it is best to make the sufferer as comfortable as one can, and to let him then remain where he is until seen by the doctor. But if he must be moved, in a cart for instance, or on a hurdle, the danger and pain of jolting

should be lessened as far as possible by spreading a thick layer of hay or straw, or rugs or sacking,—or at least two or three smoothly folded coats—for him to lie on. He must be lifted and laid down with the utmost steadiness and gentleness, and it should be one person's special duty to support the injured part or limb during the whole time that this is being done.

In old people the bones are apt to grow thin and brittle; they thus break more easily. And the "neck" of the thigh bone sometimes gives way under very slight violence, or even under the mere weight of the body. Thus, if an old person suddenly feels pain in one hip joint, with lameness of that leg or inability to stand, the sufferer should be carefully got to bed and be seen by a doctor. The fact that the sufferer may be able to stand and even walk after a fashion, does not necessarily prove that the bone has not been broken; but, if a fracture has taken place, such movements will assuredly make it worse, and possibly altogether prevent healing, in the end.

Dislocations.—When the bones forming a joint are forced apart and displaced, so that when the force is removed they do not return to their proper position, the bones are said to be dislocated or put "out of joint." When the bones are replaced in their proper position and the movements of the joint restored, the dislocation is said to have been "reduced." A dislocated joint is fixed, painful, and distorted in shape. Many dislocations require special knowledge for their proper reduction, and misapplied efforts may easily make matters worse. Moreover, the violence which produced the dislocation of the joint may, at the same time,

have caused a fracture of one or other of the bones concerned. Hence, it is best to do no more than place the injured part in that position which causes the least discomfort, supporting it thus by a sling or bandage, and take or send the sufferer to a doctor. If a finger or toe be dislocated, *one* steady, straight pull may be tried; should this be effectual, the dislocated bone will be heard and seen to slip into place with a snap, the joint will resume its natural shape, and the power of bending it will be restored.

Rough handling of a little child's limbs may produce dislocation of its small joints, or—even more easily—may separate the end of one of the long bones from its shaft; for these parts do not grow firmly together by bony union until a much later age. Therefore young children should not be pulled up suddenly, or swung round by the arms. If a little child walking beside an older person and holding the latter's hand should stumble heavily, it should not be pulled up sharply with the idea of saving it from falling, but rather "eased down," as it were, towards the ground. The slight bruise or scratch which might result from a fall thus gently managed would be but a trifling thing compared with the life-long injury or deformity which might result from suddenly and forcibly tugging at the child's hand when the whole weight of its body was sustained by that one limb.

Any swelling, redness, or pain, restricted movement or apparent loss of power in or about the joints of a child's limb should be promptly treated by a doctor.

LESSON XXXV

BURNS AND SCALDS: BITES AND STINGS: FOREIGN BODIES IN EYE, EAR, NOSE, MOUTH AND THROAT

QUITE apart from the serious risks which attend "playing with fire," burns and scalds are common accidents —though almost always due to "carelessness" of some kind and in some degree. Everyone should know the best thing to do at once in such cases; and also what to do, and what not to do, if the clothing takes fire.

You have learned that in order to start a fire and to keep it going, it is necessary not only to have the fuel, but also to supply air,—without the oxygen of which the fuel will not burn; and you probably also know that it is much more easy to light an ordinary fire from below than by setting fire to paper and wood placed on the top of the coal. Again, if an ordinary paper spill be lighted and held upright —the lighted end uppermost,—the flame grows more and more feeble and soon goes out; for the hot gases which form the flame are lighter than air, and therefore rise upwards, away from the unburned paper: moreover, rising thus, they create an upward draught of colder air which tends to chill the paper and to prevent its catching fire readily. But if the spill be held with the lighted end downwards all these conditions are reversed, and the whole length of the spill is very soon on fire. The flame ascends into contact with

unburned paper, and its heat makes that paper more easily take fire, while the upward draught of air thus produced carries to the heated paper an abundant supply of the oxygen which is necessary to its burning.

To extinguish a fire.—You can understand, therefore, that if **a person's clothing** takes fire, one of the worst things he or she can do is to stand upright—for the flames will then spread quickly upwards. But a still worse thing would be to run about, for this would only "fan the flames," as we say, bringing a greater amount of air into contact with the clothing, and so enabling it to burn more fiercely.

Now, you will see that should a person's dress take fire, she should *instantly* throw herself down flat on the floor (so that the flames may not spread so quickly) and roll over and over so as to "crush out the fire" by pressing the burning material so closely to the ground that the air (without which it cannot continue to burn) may not readily reach it—much in the same way that we extinguish a burning match by throwing it on the ground and then stamping on it.

If the person whose clothes are burning can pull over her something which does not easily take fire, such as a woollen hearth-rug or tablecloth, or a thick coat, and roll herself up in that, the flames will be still more effectually put out.

Hence, if you see a person's clothing on fire, throw her flat on the ground at once, and, if possible, cover her with a coat or rug or blanket, or anything of that kind which may be at hand—pressing it down firmly over the burning part—so as to smother the flame. Sometimes a fire is started by the breaking or upsetting

of **a paraffin lamp.** In such a case remember that it is worse than useless to throw water over the flames; the lighter paraffin floats on the water, and the flames are carried further. Earth or sand, if either be obtainable, may be thrown freely on to the flames; and if a jug of milk be at hand, it may be used in the same way with good effect. Failing these, some thick woollen material, such as a rug or blanket, soaked in water, may be thrown over the flames and pressed or trodden down, so as to smother them. (The previous wetting of the blanket prevents it from acting as a wick for the paraffin.)

Should **a room** be found to be on fire, do not open the window, nor (unless absolutely necessary) keep or leave the door open—because the more freely air is allowed access to the flames, the more fiercely can the fire burn.

Ordinary **flannelette** is the most dangerous of all dress materials as regards risk from fire, since it readily takes fire and burns with fury. It should never be used for dresses, and especially not for the dresses of small children. Cotton wool—sometimes employed in connection with Christmas entertainments, etc.—is even more dangerous.

Burns and Scalds.—These may be classed together, and are of all degrees of severity, from a slight and superficial redness of the skin to an injury involving destruction of the skin and of the muscular and other deep tissues beneath it. But a burn which affects a large surface, though but slight in degree, is more dangerous to life than a deep burn of small extent. If the true skin is destroyed, a permanent scar is left after the healing of the wound.

The destruction wrought by scalding steam is much more severe than that which is produced by water of the same temperature. In any severe burn or scald **the first thing to do** is carefully to *cut* away the clothing from the wounded part, without breaking the blisters, leaving any part which is sticking to the skin in its place until it can be soaked off with warm oil. Blisters should be opened in one or two places by snipping one or more small holes in them, near their edges, with the points of a pair of scissors, so as to let their contained fluid drain out gradually. Next, the burnt surface should be protected from the air—and this will do much to allay pain—by covering it with narrow overlapping strips of thin clean linen soaked in sweet oil, or in a mixture made by well shaking together equal volumes of oil and lime-water, and lightly bandaging a thick layer of cotton wool over all. Or the burn may be covered with two layers of thin linen well sopped with whitening and water mixed to a thin cream; but in such a case, the dressing must be *kept* damp by occasionally sprinkling its surface with tepid water squeezed out of a clean sponge. If none of these plans can be adopted, the burnt surface may be thickly dredged with ordinary dry flour or powdered starch.

Small burns and scalds may be covered with a fold or two of clean linen soaked in a strong solution of the *bi*-carbonate of soda (such as is used in making baking powder) or in a *weak* solution of kitchen (washing) soda.

Lastly, the burnt part must be kept at rest in a comfortable raised position.

Bites and Stings.—Bites produce wounds which are always poisoned, since the teeth of animals and the jaws of insects are never clean; and there may be special danger from the bites of dogs, cats, and horses, etc., and of some snakes. In this country there is only one poisonous snake—the viper or adder—and its venom is so feeble that it is practically never fatal to persons in sound health. If one's mouth is healthy and free from sores, there is no harm in sucking the bite vigorously, after tying a handkerchief or bandage tightly round the part just *above* the bite. The bitten part may then be placed in a large basin of warm water and moderate bleeding from it encouraged. A strip of clean rag soaked in warm water may then be kept bound over it, until it has been seen by the doctor.

The stings of wasps, bees, and hornets, the bites of mosquitoes and of some flies, are apt to produce considerable pain and swelling in some persons. They may be covered with two or three folds of clean rag soaked in one of the soda solutions mentioned under BURNS (page 88).

Foreign bodies in the Eye, Ear, Nose, etc.—In this case, a "foreign" body means some substance which is not natural to the place in which it is found, and which has no business to be, or to remain, there. Thus, a grain of sand, or a loose eyelash, even, if it gets into the eye, is a "foreign" body while in that situation; and so is a fish-bone in the throat.

The Eye.—If the foreign bodies are very small, like dust, they can often be got rid of by plunging the face into a basin of tepid water, opening and shutting

the eyes under water, and moving the eyeball about in all directions at the same time.

If the body can be seen when the eyelids are kept open, it is best removed from the surface of the eye by gently wiping it away with the corner of a clean handkerchief, twisted to a point, and slightly damped, or by a damp camel's-hair brush.

Often the foreign body is felt to be lying beneath one or other lid. If it be beneath the *lower lid*, this should be pulled gently down as far as it will go, by the tip of the finger, the eye looking upward, and the foreign substance removed as described above.

If the body be beneath the *upper lid*, it may sometimes be removed in the following manner. It depends upon the fact that the foreign body tends to stick more to the inner surface of the lid than to the smooth eyeball. The eye is made to look downwards as far as possible—thus rolling the foreign body a little nearer the edge of the eyelid. The eye being still kept looking downwards, the eyelid is lifted away from the globe by the finger and thumb grasping its outer skin, and the eye rolled upwards, and the lid is then allowed to fall back into its place upon the globe. Then the eye is again directed downwards, and these manoeuvres are repeated in succession for a few times, until the body is felt or seen to have reached the edge of the eyelid, when it may be removed.

After a foreign body has been removed, the sensation as though it were still "in the eye" may persist for some time. This trouble is best treated by bathing the eye plentifully with cold water, or by placing a drop or two of oil (castor oil is best) in the outer angle of the

eye, and moving the eyeball about gently, so as to lubricate the chafed surface.

If the particle can be seen, but cannot be detached from its position by gentle measures; if nothing can be seen, but acute pain persists; or if a sharp piece of metal, broken glass or grit, or a spark of burning coal, or similar thing, have got into the eye, oil should be placed in the eye, which should then be lightly bandaged, and seen as soon as possible by a doctor.

The Ear.—Anything in the ear should be attended to by a doctor as soon as possible. Any attempts to get the foreign body out by unskilled persons may result in very serious injury. But flies or small moths, which sometimes find their way into the ear, may easily be got rid of by pouring ten or fifteen drops of warm glycerin or oil into the ear from a teaspoon.

The Nose.—Foreign bodies may sometimes be expelled from the nose by making the child blow vigorously through the affected nostril, the other one being kept closed. Should this prove unsuccessful, no attempt should be made to extract the intruder, but the sufferer should be taken at once to the doctor.

The Mouth.—If the foreign body can be seen, it may sometimes be extracted by hooking behind it the end of a finger introduced into the mouth. (The finger can be protected from being bitten by placing a cork or the handle of a walking stick between the back teeth of the well-opened jaws). Otherwise the sufferer should be seen by a doctor without delay.

A foreign body lying far back in the throat may sometimes be got rid of by proceeding as indicated under CHOKING (page 195).

Broken Needle, etc.—It is dangerous to hold pins or needles between the lips, for they may be accidentally swallowed. It is also dangerous to leave them lying about upon a table, or stuck into a table-cloth or into the body of a dress or pinafore; for they may drop on to the floor, and then be trodden upon by someone's naked foot; or may penetrate a hand which is being passed over the table or the dress, as the case may be. If a piece of broken needle or the like has penetrated the skin and disappeared beneath the surface, so that it cannot easily be pulled out, the sufferer should be taken to a doctor at once; for the needle may quickly travel for some distance from its point of entry if the muscles of the part are kept in motion to any extent. Hence, care must be taken to prevent all movements of the injured part—particularly if this be a limb, and more especially if the needle have entered near a joint —before the doctor sees it.

LESSON XXXVI

FAINTING, SICKNESS, FITS, CHOKING, HICCOUGH, NOSE-BLEEDING, BLEEDING FROM THE STOMACH AND FROM THE LUNGS

Fainting.—Fainting occurs whenever the heart does not send to the brain enough blood to enable it to go on doing its work properly. The lessened blood-supply to the head is shown by the increasing pallor of the sufferer's face, and when the brain receives so

little blood that it is no longer able to control the muscles which hold the body upright, the latter cease to do their work, and the individual falls to the ground unconscious.

It is easy to see that a weak or tired heart can less easily pump blood up to the head when a person is standing erect than when she is lying down flat, and that the blood will reach the brain still more easily if the head be placed lower than any other part of the body. Hence we can understand that the best way to prevent fainting when this is threatened, and to restore to consciousness persons who have fainted, is to lay them down flat on the ground or on a couch (*not* placing a pillow under the head), near an open window, and to loosen all the clothing about the neck, chest, and waist —so that there may be no obstacle to the free movement of both heart and lungs.

A threatened faint may often be arrested by quickly placing the sufferer in a chair, with the knees widely separated, and thrusting the head down *as far as possible* towards the floor, between the knees. When the backs of the ears have become quite red, we know that blood is once more flowing freely to the head, and therefore to the brain. The head and shoulders may then be gradually raised, and the sufferer made to lie down for a while until quite recovered

Many people think that when a person has met with an accident or is feeling faint or ill, the first thing to be done is to give some stimulant, such as brandy or whisky. This is not wise, and in some cases, as when there is bleeding, for instance, may only make matters worse. Any ordinary hot drink,

such as tea, coffee, hot milk (or even plain hot water), will be useful if there is faintness or shock; but, as a rule, stimulants should only be given at the express bidding of a doctor.

When the occupants of a room complain of faintness, the reason may be defective ventilation,—and this point is one which should always be remembered and attended to in such circumstances.

Sickness (Vomiting).—This may be due to the same causes which tend to bring on fainting. It is, of course, also often caused in children by taking too much or improper food, and it is an early symptom in some forms of illness. Rest, lying down (with some warm covering, if chilliness is complained of), and the sipping of water as hot as can be comfortably swallowed, form the best emergency treatment. If a person who is already unconscious begins to vomit, the head should be at once turned to one side, so that the vomited matter may easily escape from the mouth, and not be drawn into the lungs.

Fits.—In the true epileptic fit there is complete loss of consciousness; and there are usually convulsive movements, which may be extremely violent; but the sufferer should not be forcibly held down. A pillow or folded coat should be placed beneath the head to save it from injury: the clothes should be loosened, especially about the chest and waist, and a piece of wood, the corner of a small book, a cork, a ruler, or the handle of a walking stick should be held between the teeth to prevent the tongue from being bitten. The sufferer is generally very drowsy after the fit, and should be allowed to go to sleep quietly in an airy,

darkened, and quiet room, the body being well covered so as to maintain a comfortable warmth.

In hysterical fits consciousness is not lost; there is apt to be some struggling, with screaming or shouting, laughter and tears. Sympathy and "fuss" only make the sufferer worse, and all spectators and officious friends must be kept away. The best treatment is quiet, gentle firmness, with a dash of quite cold water in the face. Hysteria is not a wilful pretence of illness, but is a sign of ill-health, and calls for the care of the doctor, and especially for wise and reasonable treatment by parents and teachers.

Choking.—The simpler form, such as is produced when a drop of water or a crumb of food "has gone the wrong way," may often be arrested by holding the breath for a second or two, or by saying "Ah" loudly —especially if the tip of the tongue be first grasped by a handkerchief held between the finger and thumb and drawn strongly and steadily forward.

In severe cases, when the obstruction is larger and has been drawn far back into the throat, and the face begins to grow dusky and the sufferer unconscious, the danger is great and imminent. A doctor should be sent for *at once* (care being taken to state the nature of the accident, in order that he may come provided with instruments for opening the windpipe should this be necessary). Meanwhile attempts may be made to remove the obstruction: a thick cork or a piece of wood having been placed between the back teeth on one side, a forefinger may be passed as far as possible into the back of the mouth and an attempt made to hook up the obstruction; this is likely to induce retch-

ing, which will help to the same end. Should the finger prove just too short to be effective, a piece of wire if obtainable (a foot of ordinary bell-wire will answer) may be fastened round the finger with a projecting loop, and the attempt repeated.

Should this prove unsuccessful, the sufferer is seated in a chair with a firm back, and another person, standing behind him, crosses his arms over the front of the sufferer's abdomen just below the ribs, and then suddenly and forcibly compresses the abdomen against the back of the chair. The violent upward thrust thus produced will often be followed by the ejection of the obstruction. Should the breathing have failed before the obstruction has been removed, artificial respiration must next be resorted to without delay (see DROWNING, page 198).

Hiccough.—Slight cases may be cured by taking a deep and prolonged breath, or by swallowing a large draught of cold water: sometimes, by applying quite cold water to the skin beneath the lobes of the ears. Grasping the tip of the tongue by the thumb and forefinger (covered by a handkerchief to prevent slipping), drawing it forward out of the mouth and maintaining a steady pull on it for a minute or two, is often successful in stopping the spasm.

Severe and continuous hiccough is very exhausting, and may be a symptom of serious illness; in such a case a doctor should be consulted.

Nose-bleeding, if due to a blow on the nose or other local injury, may call for special treatment (see INJURIES TO THE NOSE, page 168). In ordinary simple cases, the clothing round the neck should be loosened,

and the sufferer should sit with the head held up (*not* bending the neck forward), and hold both hands with the arms extended straight above the head: as the hands grow pale, the bleeding will usually lessen. Cold or iced water, or a folded handkerchief wet with cold water, may be applied over the nose. If the bleeding is severe and persistent, the sufferer should lie down, with the head somewhat raised, in a cool airy room, and the legs should be brought over the edge of the bed and the feet immersed in a bath of mustard and warm water, while the doctor is sent for.

Bleeding from the Stomach.—The blood is brought up by vomiting, and is more or less dark and clotted, and may even be black in colour.

The patient must be kept absolutely quiet, and should be treated as advised under BLEEDING FROM THE LUNGS (see next paragraph), while the doctor is being sent for.

Bleeding from the Lungs.—The blood flows from the mouth in a gush, or is coughed up, little or much at a time, and is bright red in colour. But some of this blood may be swallowed, and afterwards vomited, in which case its colour will be dark. In either case the sufferer should be laid on a bed or couch, with the head slightly raised, in a cool airy room, the body being so covered as to be comfortably warm. Absolute quiet and perfect rest must be enjoined: the patient should not be undressed until after the bleeding has ceased; and he should be forbidden to talk or to move his limbs —this should be done for him if their position becomes uncomfortable. Small sips of cold water may be given, if liked; and fear and restlessness should be allayed as

far as possible by a quiet cheerful demeanour of confidence on the part of those about him, while the doctor is summoned. A first attack of bleeding from the lungs, however severe, is hardly ever fatal.

LESSON XXXVII

DROWNING: SUFFOCATION BY COAL GAS, SEWER GAS, AND WELL GAS: ELECTRIC SHOCK: SUNSTROKE

Drowning.—"Prevention is better than cure": if every boy and girl had learned to swim well, fatal cases of drowning would be comparatively rare.

Death by drowning is death from suffocation by water. Consciousness is lost before death occurs, and if the air passages can be cleared, and oxygen, in the form of fresh air, introduced into the lungs *in time*, the apparently drowned person will recover. Every second is of value: there must be no delay in endeavouring, first of all, to re-establish respiration on the spot. Since natural breathing has ceased, similar movements of the chest and lungs must be produced by means of what is called **Artificial Respiration.**

The sufferer should be got out of the water as quickly as possible, and carried to some dry and sheltered spot (if close at hand). Clothing about the throat, chest, and abdomen should be loosened, and the mouth and throat rapidly cleared of mud, weeds, etc.,

by the finger and a handkerchief. He should then be rolled over on his face, his head turned to one side, his tongue drawn forward, and a piece of wood or the tightly-twisted corner of a handkerchief thrust between the teeth on one side of the jaw, to keep the mouth open. The operator then kneels or squats by the side of the patient, or across him, places his hands over the lowest ribs on each side (Fig. 67) and swings his body

FIG. 67.—Artificial Respiration: relaxing the pressure on the chest walls, to allow the chest and lungs to expand and draw in a supply of fresh air—as in Inspiration.

forward (Fig. 68) and backward, so as to allow his weight to fall vertically upon his wrists, and then to be removed, in alternating rhythm. The pressure is exerted gradually and slowly for about 3 seconds; then removed for 2 seconds; and then again applied,—and so on; this pressure and its removal (producing (*a*) compression of the chest and abdomen—emptying the lungs,—and (*b*) inflation of the lungs, by the resilient expansion of the chest-walls while the pressure is

relaxed) occupying together about 5 seconds, or being repeated 12 times in each minute.[1]

This, the "prone pressure" method of performing artificial respiration, is superior to any other, because (1) it is fully efficient, securing a larger exchange of air than by other means; (2) it is simple and easily learned; (3) it allows the tongue to fall forward, and mucus, etc., to escape readily from the mouth and air

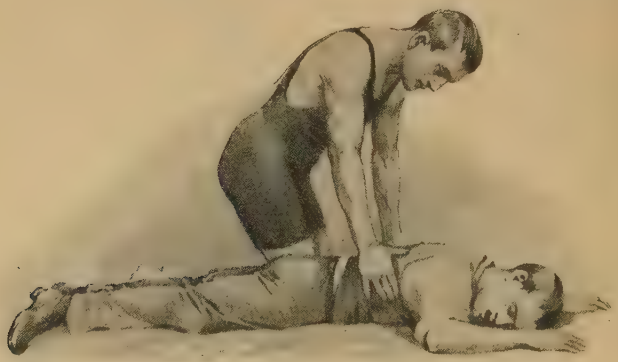


FIG. 68.—Artificial Respiration: compressing the chest and thus expelling air from the lungs, as in Expiration.

passages; (4) it can be carried out by a single individual without fatigue.[2]

If other persons are present they can be usefully employed—one in summoning a doctor, another in fetching hot blankets and dry clothing, and others in drying and vigorously chafing the limbs and body of

[1] It is well worth while learning to count seconds accurately,—up to 30, say, (half-a-minute). This power is easily acquired by a little practice, and is often of real value.

[2] Prof. Schäfer, F.R.S.

the patient—taking care not to interfere with the movements of the operator.

As soon as *natural* breathing begins to be established (its first indication is often a kind of sigh), care should be taken to make the artificial movements for inspiration and expiration at times which correspond with the natural ones as far as possible, and not to interfere or clash with them.

When the natural breathing has been fully established, the patient should be put to bed between warm blankets, with hot bottles to the feet and armpits. So soon as the patient can swallow, a cup of hot coffee may be given with advantage. Alcoholic stimulants, unless specially ordered by the doctor, are better avoided.

In every case of apparent death by drowning, the movements of artificial respiration should be steadily persevered with as long as there is any hope of recovery. In several desperate instances, life has been restored after many hours by this means.

Suffocation by Coal Gas, Sewer Gas, Well Gas ("choke-damp"), Acetylene Gas.—These cases are, in one sense, even more serious than those of drowning; for, while the drowned person is starved for want of oxygen, those suffering from the breathing of coal gas and the like, have not only been deprived of fresh air, but have been also poisoned by the inhalation of harmful gases.

In all these cases, too, the first thing to be done is the removal of the sufferer into *fresh* air, and the second is the performance of artificial respiration (page 199). In other respects, also, proceed as in the case of the apparently drowned.

In attempting to remove an unconscious person from a room into which coal gas has been escaping,—first, while standing outside the door, fill the lungs by taking a deep breath of fresh air; then open the door quickly, leaving it open, run quickly to the window and break three or four panes of glass by thrusting the *elbow* through them; take another deep breath of fresh air through the opening made in the window, and then try to lift or drag the unconscious person out into the passage—shutting the door of the gas-filled room afterwards. Of course, whenever there is a smell of escaping coal gas, *no* naked light (lamp, candle, or matches) should be used, for fear of producing an explosion.

Apparent Death from Electric Shock.—Lay the sufferer on the ground in fresh air—on damp ground, if possible,—and perform artificial respiration (page 199) while the doctor is sent for.

Sunstroke and Heatstroke—True sunstroke is rare in the British Isles, but heatstroke is not uncommon amongst those exposed to a high temperature, especially under conditions of bad ventilation, or in close, hot weather. The sufferer should be laid on his back in the coolest and shadiest spot available, all clothing loosened, and cold water dashed on the face and chest,—bystanders being kept from crowding about him. In very severe cases, the breathing may cease,—when artificial respiration should be at once resorted to.

LESSON XXXVIII

POISONS

In every case of poisoning *a doctor must be sent for at once*, and he should be told the name of the poison taken (if known). The following directions are intended only to indicate what may be safely done in certain cases before a medical man has arrived on the scene.

General Principles.—There are certain general principles which must be understood and remembered, if aid is to be rendered intelligently. In dealing with a case of poisoning our object is twofold:

First, to remove from the body as quickly as possible so much of the poison as has not yet been absorbed—*when this can be done safely*, and, secondly, to counteract—or render harmless—what cannot be removed.

Some poisons, such as arsenic, tend to produce vomiting, and thus help to secure their own removal to a large extent. Others, such as opium, do not: and then it may be necessary to produce vomiting. On the other hand, some poisons, like the strong acids and strong alkalies (for example, spirits of salt and caustic potash), so damage the tissues of the gullet and stomach that the strain of vomiting may tear through the injured part; in such cases, vomiting must be guarded against most carefully, and our hopes of recovery must depend upon neutralising the poison in the stomach.

In some cases, as in poisoning by prussic acid and its compounds, by opium, and by carbolic acid, and in those which result from breathing poisonous gases, the breathing may cease, and when this happens artificial respiration is called for.

We may not know, and the sufferer may be unable to tell us, what it is that has been taken; but if there are stains—white or reddish or yellowish in colour—about the mouth and lips, and also perhaps on the adjacent clothing, we may assume that some **corrosive liquid** has been swallowed, and we then know that it would be highly dangerous to attempt to make the patient vomit. In such a case we may be able to learn whether a strong *acid* or a strong *alkali* has been taken. This knowledge is important, because we know that when acids and alkalies are mixed together they neutralise one another. Thus, the poisonous hydrochloric acid (spirits of salt), when mixed with kitchen soda, combines to produce harmless common salt.

Hence, if we know that any **strong acid** has been taken, we may safely give some harmless alkali mixed in water—lime-water, whitening and water, powdered chalk, or even common soap and water. On the other hand, if a **strong alkali** has been taken, we may neutralise it by giving a *weak* acid, such as vinegar and water, lemon juice, or lime juice.

In the next place, we may give some bland fluid, that is, a fluid neither irritating nor stimulating, such as white of egg or milk, to act as a sort of protective varnish to the lining of the injured stomach.

Sometimes, especially when strong acids or alkalies have been taken, there is severe "shock"—faintness,

pallor, and feeble pulse. To meet this, the patient must be covered with hot blankets, and hot bottles or hot bricks wrapped in flannel must be packed alongside the body and lower limbs.

When the poison is one which produces excessive vomiting, the severity of this may be checked by making the patient lie down and giving to him sips of cold water, or of water as hot as he can swallow, or pieces of ice to suck.

When it is desirable and safe **to produce vomiting,** this may be effected by giving a pint of tepid water (or half a pint of warm water with a tablespoonful of mustard or of salt stirred up in it), and then tickling the back of the throat with a feather, or with the finger, until free vomiting occurs.

As much as possible of the vomited matter should be kept in a bowl or basin for examination by the doctor.

Brief directions for use in connection with some common poisons are given in a table at the end of this book.

LESSON XXXIX

EARLY SIGNS OF ILLNESS: EMETICS, POULTICES, AND FOMENTATIONS.

EVERY sick person has a much better chance of recovery if his condition is recognised at the outset, and if he is properly treated as a sick person from the beginning of his illness. Constant anxiety and

"fussiness" is not wisdom: but if a child seems "out of sorts" in any way it is far wiser to put it to bed at once and keep it there for twenty-four hours, feeding it only on simple liquid food and water the while, and to find it quite well again at the end of that time, than to allow an illness to develop some serious complication through lack of timely attention. Should the child seem to grow worse, or be no better at the end of twenty-four hours, it should be seen by a doctor.

Early Signs of Illness.—**Diarrhœa and Vomiting** are not always due merely to over-feeding or to some improper kind of food: they may depend upon serious mischief within the abdomen, or even in the brain: and, if persistent, always demand medical attention. Rest in bed is necessary in any case; and frequent sips of water as hot as can be comfortably swallowed may afford relief. All other food is better withheld.

In young children, **convulsions** (fits) often occur at the beginning of an illness, and these correspond to the shivering attacks which are common in older people at such times. If the skin and head feel cool, the whole body may be immersed in a hot bath, or in a mustard bath for ten minutes, then quickly dried, and the child put to bed again between the blankets. But if the skin and head feel very hot, a bath of quite cold water for five minutes is more useful, and may be repeated if the convulsion recurs.

Twitching of the face, grimaces, restlessness of the limbs or of the whole body, clumsy movements, a tendency to hold things awkwardly or to drop them with apparent carelessness, are not always merely bad or careless habits: they often indicate the develop-

ment of **St. Vitus' Dance.** In such a case a child needs rest (of both mind and body), good feeding, and careful management, as well as medicine.

In little children, constant restlessness, frequent movements of the head on the pillow—so that, sometimes the hair at the back of the head gets worn quite thin,—and a wailing or peevish cry, are indications of serious illness. Sometimes the early stages of **inflammation of the ear** (always a dangerous thing) is first shown by the infant's always crying when the ear is touched or pressed, or while that side of the face is being washed.

On the other hand, a baby which is sometimes described as being "always good"—one which lies still in its cot for hours together, and cries, perhaps. only when it is moved or handled, and perspires freely about the head—is really suffering from illness, and should be seen by a doctor.

A child which is given to crying at night and starting in its sleep, especially if it has a habit of "saving" one leg—by standing so as to throw the weight of its body on the other one; or which complains of pain in the knee after standing or walking, and may sometimes limp slightly, is probably suffering from **disease of the hip joint.**

If a child becomes less active than formerly, and is more easily tired, and especially if it shows a tendency to lie about on the floor whenever possible, there may be commencing mischief in some part of the spine or other joints.

Frequent or constant headache, squinting, unusual drowsiness or wakefulness, especially if associated with

any discharge from the ear, are signs of serious illness.

A growing tendency to stooping or to rounded shoulders, or to the "growing out" (undue prominence) of one shoulder, calls for medical examination and advice.

So do sore throat, persistent hoarseness, snoring during sleep, excessive perspiration at night, habitually sleeping with the mouth open, and a chronic or frequently recurring cough or cold in the head.

A cough which is worse at night than during the day, especially if it is apt to be followed by vomiting, commonly marks the beginning of **whooping cough**.

Whenever a child appears to be losing its natural activity and energy; to show an alteration in temper or to be becoming peevish and irritable; to lose its appetite, or grow thin and pale, a doctor should be consulted.

Emetics.—Substances which produce vomiting are called emetics. Tepid water, a tumblerful at a time, is the simplest emetic: its action is made more powerful if a tablespoonful of mustard powder or of common salt is mixed with each tumblerful; and vomiting may be hastened by tickling the back of the throat with the tip of the finger (a thick cork or piece of wood having first been placed between the jaws on one side, so as to prevent the finger from being bitten), or by a feather.

The sipping of **hot water** tends to relieve vomiting, when once the stomach has been emptied of irritating matter. A small mustard plaster (p. 212) applied to the "pit of the stomach" also helps to relieve nausea and to check vomiting.

Baths should not, as a rule, be given sooner than two hours after a meal.

The **Cold Bath** has a temperature not above 60° F. It should be taken quickly, should always be followed by a brisk rubbing of the whole body with a dry rough towel, and rapid dressing; and should produce a feeling of pleasant glowing warmth in the skin. Very young children as well as feeble and elderly folk should not take a cold bath: nor should those in whom it produces a feeling of chilliness and depression, or whose fingers and feet become cold and white or blue after it. But such persons may generally be rapidly sponged all over with a spongeful or two of cold water *while standing in a hot bath*, with benefit.

The **Cool Bath** has a temperature between 60° and 70° F. The **Tepid Bath** is between 85° and 95° F., and the **Warm Bath** from 95° to 100° F.

The **Hot Bath** has a temperature of from 100° to 106° F. In preparing a hot bath the cold water should always be put in first, and the hot water then added; the two being well mixed, and the bath frequently tested with the bath thermometer until the desired temperature is reached. If a thermometer be not at hand, the temperature may be gauged by dipping the tip of the bared *elbow* into the water from time to time; the hand is not sufficiently sensitive to be used safely for this purpose.

When the bath is small, as for a little child, a blanket may be thrown over it, after the child has been immersed (not, of course, covering the head or face), in order to retain the heat to some extent and to prevent the water from cooling too quickly.

The Mustard Bath.—Put two tablespoonfuls of dry mustard powder into a piece of old thin linen—such as an old handkerchief—twist it up loosely and "swish" it about in the hot water, squeezing and kneading it with the fingers the while, just before the patient enters the bath—which should be as hot as can be borne without discomfort. The patient may remain in the bath for seven to ten minutes, or until the whole surface of the body becomes a bright pink colour.

Severe irritation of the skin may often be much relieved by a **Starch Bath**—a large bowl of freshly made starch being added to comfortably warm water. After this bath, the skin should be gently *wiped* dry with a soft cloth or towel, with as little rubbing as possible.

Poultices.—To make a good **linseed poultice,** it is necessary to have everything made hot beforehand, to see that the water is actually boiling, and to waste no time in the mixing. If the poultice has to be carried for any distance to the patient, or has to be kept hot for a little time before being applied, two large plates should be put to get hot in the oven, and the poultice when made should be at once placed between them. Use, if obtainable, the freshly *crushed seed,* not the ground linseed meal.

1. Hang a clean dry towel before the fire to get warm. Take a piece of old linen or calico, an inch or two larger each way than the place which the poultice is intended to cover, and spread it flat on a table or dresser. Have ready a broad-bladed knife.

2. Scald out a basin of suitable size with boiling water, heating a large spoon at the same time.

3. Pour sufficient *boiling* water into the basin: and with one hand sift the linseed quickly into the water, stirring and mixing them at the same time with the hot spoon, until the proper consistence has been reached; the meal and water should then form a coherent mass which is neither sloppy nor crumbly.

4. Quickly empty the contents of the basin out upon the piece of linen, and rapidly flatten and spread it out evenly by means of the knife-blade (frequently dipped into hot water) to the thickness of about three-quarters of an inch, to within an inch or so of the edges of the linen: lift these edges up and turn them over upon the edge of the poultice, to which they will adhere. If properly made, the poultice may now be handled and folded or rolled up without coming to pieces, nor will it stick to the skin.

It will, at first, be too hot for use; but it should be applied, as hot as can be borne, *directly to the skin*, and kept in its place by the warm folded towel placed over it and fastened by safety pins.

To obtain the best results, a poultice should be changed every two hours, and never allowed to remain for more than three or four hours. When it is removed from the skin (by rolling it up upon itself), the skin should be rapidly wiped dry and clean with a warm soft cloth, and another poultice (ready prepared), or a piece of thick warm cotton-wool or dry warmed flannel put on in its place.

If there be any sore or inflamed spot on the skin which the poultice is to cover, this should be protected by a piece of linen, of suitable size, smeared with vaseline

or cold cream and applied to the skin before the poultice is put on.

It is wrong to apply a linseed poultice, unless *very* small, to the *front* of the chest—especially in the case of a young child. The poultice has to be lifted many times a minute in the act of breathing,—and this extra effort may prove exhausting to a feeble patient, especially if the breathing be already embarrassed.

A **Mustard Poultice** is made in a similar fashion, using equal parts of linseed and mustard (less mustard if the skin be delicate or already reddened); but the water should *not* be boiling, only so hot as can just be borne by the hand,—or the mustard will have little effect. A rather simpler plan is first to make an ordinary linseed poultice, as before described, and to dredge a little mustard over its surface just before it is applied to the skin. Or the mustard poultice may be made by mixing equal parts of mustard and flour with hot (not boiling) water.

A **Mustard Plaster** is made by spreading mustard, mixed into a paste with a little warm water, upon a double fold of linen, and applying it directly to the skin.

The skin of some persons is much more sensitive to the action of mustard than is that of others. Hence, as soon as the mustard poultice or plaster is said to be "stinging" or "burning," a corner of it should be lifted up and the appearance of the skin examined. If it already looks to be decidedly reddened, the poultice may be removed. The patient should not be permitted to go to sleep with a mustard poultice or plaster in place.

Applications of mustard should not be made to any surface which is inflamed or acutely reddened, or to which turpentine has recently been applied (even though the skin be not reddened), or blistering is likely to occur.

Vinegar must never be mixed with mustard poultices or plasters.

The Bran Poultice.—Bran may be used in the place of linseed, if the latter be not obtainable. It forms a very light poultice, but soon loses its heat. The addition of a little flour makes a more coherent mass.

The Bread Poultice is very light, but cannot well be used for large surfaces, as it easily crumbles and falls to pieces. A small one may be quickly made by taking a slice of stale bread without crust, placing it in a scalded basin, and pouring boiling water upon it. Place the basin in the oven or on the hob for a few minutes; then pour off the water as completely as possible, and quickly spread the remaining bread pulp upon a piece of linen cut to suitable size, as in the case of a linseed poultice.

Fomentations *(Stupes).*—Take a large strong towel, open it to its full width and lay it across a large washing basin—the middle of the towel over the middle of the basin. On the middle of the towel place a piece of flannel of suitable size (cloth will answer if flannel is not at hand) and press it down so that it lies within the basin, the towel beneath it. Pour boiling water over the flannel until it is covered and well soaked. Then fold the edges of the towel lengthways over the flannel, and let two people, each taking one end of it, twist the towel in opposite direc-

tions *as tightly as possible*, so as to squeeze every drop of water out of the flannel; the towel is then opened, the dried flannel shaken up for a moment, and then folded to the proper size, applied directly to the patient, and kept in place by a hot flannel or folded towel pinned in position.

Note.—The flannel must be wrung *dry* out of the boiling water; if this wringing be not effectually carried out, it is quite possible that the fomentation may produce some scalding of the skin.

Various applications (liniments, laudanum, turpentine, etc.), may be sprinkled over the surface of the flannel before applying it to the skin, in suitable cases.

But if a *turpentine stupe* has been applied, care must be taken to remove it directly it has produced a stinging sensation: otherwise the pain will continue to increase after it has been taken off, and the skin may be blistered.

LESSON XL

THINGS TO REMEMBER IN TENDING THE SICK

Suitable food and drink, pure air, cleanliness and exercise are all necessary to the strong and healthy person—if he is to *keep well*. They are, all of them—with the single exception of active exercise—even more needful to the sick person who has to *get well* in spite of weakness, and while engaged in struggling with illness.

Fresh Air.—Thus the cleansing and strengthening effects of fresh air are needed by the invalid even more than by the healthy; and the windows which were kept open for his welfare, day and night, when he was well, must not be closed because he has fallen ill. This fresh air he makes use of by breathing it, and he should be allowed to have it to breathe. So long as proper means are taken to prevent his *body* from becoming chilled, he cannot have too much of it; and so long as the body and limbs are kept warm, the breathing of cold air can do only good rather than harm (*except* when hoarseness of the voice shows that the larynx is inflamed; or in some cases of bronchitis, when the air should be moist and warm as well as pure).

Draughts.—Draughts, however, must be guarded against. A sick person ought always, if possible, to be nursed in a room with an open fire-place, because (whether a fire is burning or not) the current of air in the chimney greatly helps to secure the ventilation of the room. This air which passes up the chimney is drawn from the window or from the door, or from both; and the "draught" will therefore be along a line running from the window to the fire-place, or from the door to the fire-place, or in both these directions. It will almost always be possible to place the bed so that a line drawn from the window to the fire-place does not fall across the patient's head and shoulders (the bed at the same time not being too close to the fire); and any draught from the door to the fire-place can be met by the use of a screen, for which a clothes-horse or a tall chair covered with a sheet or tablecloth may serve.

If the room has no fire-place, the draught will be along the line between window and door; and the bed can be so placed that this falls across the foot rather than the head of the bed.

Bed and Bedroom.—Whenever space permits, it is wise to draw the head of the bed away from the wall of the room for a clear eighteen inches: this not only allows of a freer circulation of air about the patient, but permits of the nurse getting behind the bed when necessary, which is often a great convenience. For similar reasons, the patient's bed should not be placed in a corner of the room, or with either of its sides close up against a wall.

Strips of matting or carpet placed about the floor are preferable to the ordinary carpet: they are easily taken up and out of doors to be shaken and aired, and allow of the floor being kept clean and free from dust, etc.

All unnecessary furniture, hangings, etc., are better out of the way. Furniture and floor should be kept clean by being wiped over once a day with a slightly damped cloth—not by using an ordinary dry duster and broom, which are apt to disturb and scatter even more dust (*i.e.* dirt) than they remove.

It is much easier to nurse a sick person satisfactorily and with comfort to himself in a single bed than in the wider double bed. Whenever the illness is one of more than a day or two's duration, and especially if it is attended by fever, it is a *very* great advantage to be able to use two beds—the patient spending the night in one and the day in the other; that bed which he is not occupying being kept open, and not "made" until

just before he is moved into it. This can generally be arranged for in the case of children at all events.

When only one bed is available, it is an excellent plan to lift the patient out of it (if possible) each morning, and to make it up afresh "the other way about" (*i.e.* with the head towards the window, for example). The patient then spends the daylight hours with the light coming from behind him ; and the sunlight—which is so useful an aid towards recovery—can enter the room without distressing the patient by shining directly into his eyes. In the evening, the bed is again freshened and made up, and the patient placed in it with his position reversed.

No dirty utensils or soiled clothing should be allowed to remain in the sick room at any time.

Bedding.—For several good reasons, no healthy person, and still more emphatically no sick person, should sleep on a feather bed. An absolutely clean feather bed would be unhealthy, if only because it is so soft that it allows pressure to be made, for many hours at a time, upon soft parts of the body which are not able to bear continuous pressure without ill effects. But, although even careless people do wash the sheets and blankets of their beds from time to time because they get "dirty" from absorbing the sleeper's perspiration, etc., persons who are otherwise careful too often allow the feathers of the bed and the covering which encloses them to remain for years uncleaned, until it becomes what might be described as a huge poultice of decomposing sweat.

Quilts of any kind are bad on a bed, except to protect it from dust, etc., during the time it is unoccupied.

They are heavy and oppressive out of proportion to the warmth which they give, and they do not readily allow the escape of those exhalations from the skin which pass easily through the much more porous blanket. If more warmth is called for, an extra blanket or a rug or a coat, or even a piece of clean sacking is more healthy. There is no objection to the use of a quilt to wrap round the feet, legs, and knees of an invalid who is sitting up in a chair.

Care must be taken that the patient, especially if a child, is not covered with too heavy or too much bedclothes at night. This only leads to excessive perspiration, and favours general weakness, besides increasing the susceptibility of the skin to cold. Or the child may throw off the bedclothes, and afterwards, in the cooler hours of the early morning, become dangerously chilled. This is especially likely to happen, even though the amount of bedclothes may not be excessive, when the child has been put to bed after a hot bath. In such cases it is a good plan to place the child in its cot with only a light, comfortable covering, and to throw the extra blanket *over the cot*, so as to make a kind of roof to it (except over the head and face). An hour or so later, when the sleeping child's skin has cooled down, the blanket may be gently laid over its body.

Personal Cleanliness.—The cleanliness of the patient's person is of great importance. The *whole* body, lying on a warm blanket, which is afterwards removed, should be washed with warm water and soap once a day at least, quickly dried, and then rubbed gently but briskly with a dry and not too soft towel.

In all cases of great weakness and of severe illness this process should be carried out piecemeal, each limb and the trunk being attended to separately and in turn, so that only a small portion of the body is kept uncovered at one time. At night, if the washing of the whole body be not repeated, the face, neck, hands and wrists, and *the feet and ankles* should in any case be sponged over with warm water, and dried as already directed. This helps very much to secure quiet and refreshing sleep.

In every serious illness, and especially with old and very thin persons, there is a great risk of the formation of "bed sores." These usually begin on the lower part of the back, and are due to the combined effects of pressure and moisture. They are best guarded against by maintaining strict cleanliness, by keeping the part dry, by taking care that the sheet and the blanket on which the patient lies are always kept as smooth and free from ridges and folds as possible, and by gently moving him occasionally on to each side in turn so that the same position is not maintained for too long. If, at any time, any part of the skin shows the slightest sign of reddening or duskiness, it must be carefully *dabbed* dry with a hot soft cloth, and then immediately painted over with (1) a little spirit, and when this has dried, with (2) some white of egg and then with (3) another application of the spirit; and the doctor's attention should be drawn to it as soon as possible.

Whenever there is much fever and restlessness, great relief may be given by sponging the whole body with tepid water from time to time, followed by gentle

drying of the skin. The hair should be gently combed and brushed, night and morning.

Delirium.—Sometimes restlessness runs into delirium, and the sick person talks nonsense, imagines all kinds of absurdities, and may even become violent *It is worse than useless to contradict or to attempt to argue with a delirious person.* This would only make him more excited, and possibly provoke an outburst of violent protest on his part. But much may often be done to quiet him, if the nurse appears to fall in with his mood, and to accept his wildest statement as reasonable, while suggesting a plausible reason for a little delay in carrying out his wishes; thus she may propose some other plan which will answer even better, though it involves (for example) writing a letter first, or waiting for the important letter which to-morrow's post may be expected to bring.

If the patient is disturbed by phantoms of persons or things which distress him, the shaking and displacement of a curtain may suffice to assure him that the object in question has been got rid of; and an imaginary visitor may be spoken to, and conducted to the duly opened door and there dismissed with some parting observation, and the door closed again with the remark that he will not come again for a specified time.

If an adult patient shows indications of becoming violent, razors, knives and forks—anything which could be used as a weapon—must be quietly removed from his reach, and care must be taken to have efficient help close at hand, although no persons beyond those necessarily in attendance on him should be actually

introduced into the room before their presence is needed. In restraining a violent person, every care must be taken to avoid injuring him.

Beverages.—For the sick person, food and drink must be of the proper kind, given at the proper time and in the proper way. The doctor will indicate the kind and the amount of food which is required in the particular disease. But there is scarcely any kind of illness in which **pure fresh water** (which is, in itself, a kind of food) may not be given as frequently as the patient desires, provided only that it is swallowed in moderate amount at a time—by sips. This is best managed by giving a small wineglassful, more or less, poured into a cup or tumbler (which lessens the risk of its being spilt); and repeating this as required. Drinking may be rendered more easy by slightly raising the patient's head and neck by means of the left arm thrust under his pillow, while the right hand holds or tenders to him the cup or medicine glass.

Other beverages which may be given in place of water to allay thirst are home-made lemonade and toast water.

Lemonade is made by cutting one large or two small lemons into slices (with a *quite* clean knife), placing them in a jug with a little sugar according to taste, and pouring boiling water over them; it may be taken hot or cold, as preferred. If allowed to stand for long, a bitter flavour is developed; to avoid this, the lemons must be *very* thinly peeled (so that none of the white pith is taken away), and the boiling water poured over this thin outside peel only; the juice of the lemon (quite

free from any white pith or pips), and the sugar, should be added afterwards.

Toast Water.—Take a slice of stale bread (crust is best, as it does not turn sour so soon as the crumb does) and toast it slowly all through, without burning it. When cold, pour over it a quart of boiling water; let it stand covered until cold, and then strain through muslin.

Apple Water.—Slice, without peeling, a pound of apples, and boil in a quart of water until the fruit is soft. Strain through muslin, sweeten to taste, and serve when cold.

To keep water and other beverages cold for the sick room, place in a stone jug and wrap the jug in a cloth kept constantly wet.

Nourishing Drinks.—Rather more nourishment is contained in the following beverages, which are also useful for quenching thirst:

Barley Water.—Wash two ounces of barley (or better, boil it for a few minutes to cleanse it, then pouring the water away) and simmer it gently in three pints of water for nearly an hour. When half done, put into it a piece of lemon peel and a little sugar; strain, and it is ready for use.

Oatmeal Water may be made in a similar way.

Rice Water.—Wash two tablespoonfuls of rice, and then simmer it very gently in three pints of water for four or five hours; strain off the rice, and add more water, to make up to a quart, if necessary.

The following are valuable forms of food for the sick—

Rice Milk.—This is made like rice water, the rice

being simmered in milk instead of in water, and hot water being afterwards added if necessary to make up to a quart.

Egg Water.—The whites of two quite fresh eggs (after removal of the stringy part) are mixed with a pint of plain cold water—without beating to a froth. A little sugar may be added, if liked.

Egg Lemonade.—Dissolve two lumps of sugar in half a large tumbler of cold water; add the whites of two eggs, and mix thoroughly while adding the juice of a lemon, finally filling up the tumbler with water.

Beef Tea, as ordinarily made, is mainly a stimulant, and contains very little nourishment, because the strengthening element of the meat has been changed almost entirely into merely stimulating substances by the high temperature to which it has been exposed. It often makes a person *feel* better, for the time, because it whips him up, as it were, to draw upon his reserve strength; but it does not make him any stronger in reality, and, in the end indeed, leaves him even weaker than before, if no other real food has been taken as well.

How to make Beef Tea.—With a little trouble and ingenuity, however, it is quite easy to make beef tea which is really a strengthening food,—and that with even less than the trouble and attention required for preparing beef tea in the usual way.

Procure a clean empty preserved meat tin, from which the top has been neatly cut out so as to leave no jagged edges, and an ordinary jam jar rather smaller and a full inch shorter than the tin. A circular piece of stout tin (the top cut from the meat tin may

be made to serve the purpose) is needed, a little larger than the bottom of the jar. Pierce four holes close to its edge and equidistant from each other; and through these holes thread two pieces of stout galvanised wire (*w.w*), as shown in Fig. 69, so that the disc of

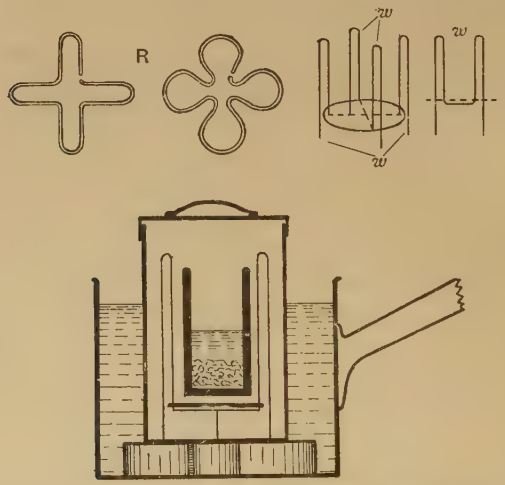


Fig. 69.—Home-made apparatus for making nourishing Beef-Tea.

tin may stand level in the meat tin a full half-inch above the bottom of the latter. The rounded upper ends of the wires should reach to within about an inch of the top of the meat tin: and they should stand so far apart, when fixed in the disc, that the jam jar may be easily slipped down between them to stand upon the disc. The meat tin ought to be provided with a closely fitting lid (fitted with a handle), though a sauce-pan lid put on over a piece of clean white paper, may be made to answer the purpose.

Lastly, take a strip of tin or of sheet lead half an inch wide and bend it into a cross or rosette (R) on which the meat tin may stand when placed in a saucepan,—this latter should be at least two inches wider than the meat tin.

To make the beef tea, cut the meat into small dice, place it in the jar and cover it with 3 or 4 inches of water. Slip the jar down between the wires on to the disc, and stand it in the meat tin (*putting no water into the latter*). Put the lid on the meat tin and place it in the saucepan; nearly fill the latter with water, and put it on the fire and let it boil gently. Although the water in the saucepan is boiling at 212° F., the contents of the jar do not rise much above 120° F., owing to the air space between the jar and the walls of the meat tin, and the meat retains almost all its nourishing properties. The only precaution needed is to see that the water in the saucepan is replenished before it has boiled away.

After two or three hours—or as much longer as may be convenient—the meat tin is taken out, the jar withdrawn from the meat tin, and all its contents poured into a basin, rubbed up smooth with a spoon, diluted with warm water and flavoured with a little salt according to taste.

General Hints.—No food or drink should be kept in the sick room, except that which is needed for immediate use.

Milk puddings should not be made with eggs added to them, for this addition tends to make them more difficult of digestion.

Whenever food, drink, or medicine is left beside

a patient, for him to help himself, such things should be placed on a table, chair, or stool three or four inches *below* the level of the bed and close to it. It is much easier for a sick or feeble person to find and lift up a cup or glass from a level a little lower than himself, than to reach it down from a height above him without accident. For a like reason, his cups, glasses, or jugs should be not more than two-thirds, or even only half, filled. If a lamp or candle be in use, shade the patient from its direct glare by placing it behind a screen, behind some projecting piece of furniture, or on the floor (not near the bed or curtains; and not in a draught).

Be very careful to wrap all hot-water bottles, etc., in flannel or cloths before applying them to the patient, so as to avoid burning the skin.

Remember that a good nurse must be not only skilful, but careful, thoughtful, kind, and patient, also.

BRIEF DIRECTIONS FOR USE IN CONNECTION WITH THE COMMON POISONS.

This table is for reference, and is not intended to be learnt by children.

ACIDS.

NAME.	TREATMENT AND ANTIDOTES.
Carbolic Acid.	Give 2 full teaspoonfuls of Epsom salts dissolved in 1 pint of warm water. Or give 30 drops of Tincture of Iodine dissolved in half a tumblerful of water. A few minutes later, induce vomiting. Then give large draughts of milk: or sweet oil ($\frac{1}{4}$ pint) stirred up in 1 pint of water: or white of eggs stirred up in water. Keep the sufferer lying down and warmly covered: use artificial respiration (p. 199) if the breathing fails.
Hydrocyanic Acid (Prussic Acid). Cyanides.	*These poisons act with extreme rapidity: hence the* **promptest** *measures are needful.* Place the sufferer in the open air, and *induce vomiting immediately* (p. 205): also, dash cold water on the head and along the spine. Use artificial respiration (p. 199), holding smelling salts to the nose at frequent intervals. Give teaspoonfuls of a mixture of equal parts of spirit (brandy, whisky or gin) and water.

ACIDS.—*Continued.*

NAME.	TREATMENT AND ANTIDOTES.
Oxalic Acid (Salts of Lemon). (Salts of Sorrel).	*Do not provoke vomiting*: but give freely of water mixed with whitening, powdered chalk, powdered wall-plaster, or lime-water. Then give large draughts of milk.
Hydrochloric (or Muriatic) **Acid** (Spirit of Salt). **Nitric Acid.** **Sulphuric Acid** (Oil of Vitriol).	*Do not cause vomiting*: but give, in plenty of water, whitening, powdered chalk, wall-plaster, or kitchen soda. If none of these is at hand, give freely of soap and water. Then give sweet oil ($\frac{1}{4}$ pint) stirred up in 1 pint of water; milk, or milk and egg; or thick gruel. Lessen the shock by covering the sufferer with warm blankets, and packing hot-water bottles, or hot bricks wrapped in flannel, along the sides, legs and armpits.

ALKALIES.

Caustic Soda. **Caustic Potash.** Soap Lye. Ammonia.	*Do not cause vomiting.* First try to neutralise the alkali by giving freely of vinegar, lemon juice, or lime juice mixed with water. Then give draughts of milk, or of white of egg and water, or sweet oil ($\frac{1}{4}$ pint in 1 pint of water). Treat the shock as directed under ACIDS.

METALLIC POISONS.

Antimony. Tartar Emetic.	*Encourage vomiting* by giving large draughts of tepid water. If vomiting has not occurred, induce it. If vomiting becomes excessive, give strong tea freely; and repeat this if the vomiting recurs. Apply a small mustard plaster (p. 212) to the "pit of the stomach.' When vomiting has ceased, give freely of milk or white of egg in water. Shock must be treated by warmth and stimulants as already described.

METALLIC POISONS.—*Continued.*

NAME.	TREATMENT AND ANTIDOTES.
Arsenic.	*Induce free vomiting at once*; encourage it, if it has begun. The best antidote is made by adding 3 tablespoonfuls of the tincture of Perchloride of Iron to a wineglassful of water and mixing this with 2 teaspoonfuls of washing soda dissolved in half a tumblerful of warm water. Give half of this when the vomiting ceases, and the remainder in ten minutes. Repeat if necessary. Or, dialysed iron may be given, 1 teaspoonful at a time, up to 10 teaspoonfuls, each dose being followed by a little common salt dissolved in water. Afterwards give plenty of milk and white of egg, or sweet oil in water, or barley water. Shock must be treated; and thirst may be allayed by cold water given in small sips.
Copper. Blue Vitriol. Verdigris.	Give *at once* draughts of milk and white of egg, or of flour and milk or flour and water. Then induce free vomiting.
Lead. Sugar of Lead.	*Induce vomiting.* Then give Sulphate of Magnesium (Epsom salts), or Sulphate of Soda (Glauber's Salts)—1 heaped tablespoonful in a tumblerful of water. Afterwards administer milk and eggs, or milk, or eggs beaten up in water, or barley water freely.
Mercury. Corrosive Sublimate. White Precipitate. Red Precipitate. Cinnabar. Vermilion. Calomel.	Give *at once* plenty of milk mixed with white of egg, or of water and white of egg. Flour and water may be given with some benefit if the above are not obtainable. *Then* induce free vomiting.

METALLIC POISONS.—*Continued.*

Name.	Treatment and Antidotes.
Phosphorus. Match-heads.[1] Rat paste.	*Induce free vomiting.* Copper Sulphate (Blue Vitriol) 3 grains dissolved in 8 tablespoonfuls of water given every five minutes until vomiting is again produced, and then every 15 or 20 minutes, is useful as an antidote as well as an emetic. Zinc Sulphate, 20 grains in 8 tablespoonfuls of water, may be used as an emetic. After free vomiting, give Old or French Turpentine, 40 drops in 2 tablespoonfuls of water, every 15 minutes for one hour; then three times a day.[2] *On no account should* German or American turpentine be given—only the Old or French Turpentine.] Give milk and white of eggs freely. *Do not give oil or fat of any kind.*
Silver Nitrate. Lunar Caustic.	Give *at once* 2 tablespoonfuls of common salt dissolved in a tumblerful of water; repeat, if vomited. *This induces vomiting.* Afterwards give large draughts of white of egg beaten up in water.
Zinc Salts. White Vitriol. Burnett's Disinfecting Fluid.	*Do not provoke vomiting.* Give large draughts of white of egg and milk. Give Carbonate of Soda (washing soda) dissolved in plenty of warm water. Give freely of strong tea.

[1] This does not apply to "safety" matches, the heads of which contain no phosphorus.

[2] Most serious symptoms are liable to develop several days after the immediate effects of phosphorus poisoning have been recovered from.

ORGANIC POISONS.

Name.	Treatment and Antidotes.
Alcohol (Acute Alcoholic Poisoning).	*Induce vomiting*: when this has taken place, give 1 oz. of Epsom Salts dissolved in a tumblerful of water. Give Sal-volatile, 1 teaspoonful to a wineglassful of water, and repeat in 10 or 15 minutes. Apply cold water to face: give hot strong coffee when roused. In severe cases, artificial respiration (p. 199) may be needed: the sufferer must be kept warm while this is being applied.
Belladonna. Atropine. Nightshade Berries.	*Induce vomiting.* Then give hot strong coffee, and teaspoonful doses of a mixture of equal parts of spirits and hot water. Keep the sufferer warm. Employ artificial respiration (p. 199), if needed.
Chloral.	*Induce vomiting.* Give hot coffee when the patient is able to swallow. Keep patient warm; rub limbs and body briskly in the direction of the head. Artificial respiration (p. 199) may be needed.
Poisonous Fungi. (Mushrooms, Toadstools). **Meat, Fish, Etc.** (Ptomaine Poisoning).	*Induce vomiting*, if this has not already occurred freely. Give purgatives (*e.g.* castor oil, 2 tablespoonfuls), unless the bowels are already loose. Keep warm. Give sips of hot coffee; and of spirits and water if necessary.

ORGANIC POISONS.—*Continued.*

NAME.	TREATMENT AND ANTIDOTES.
Opium. Laudanum. Chlorodyne. Morphine. Paregoric, etc.	*Induce vomiting.* Give plenty of hot strong coffee. Give Potassium Permanganate, 8 grains dissolved in half a tumblerful of water; or enough "Condy's Fluid" added to a tumblerful of water to make it of a deep rose colour. Rouse the patient, dash cold water on the face and neck, and keep him awake—*but do not exhaust him* by trying to make him walk about, etc. Keep the body and limbs warm: maintain a free supply of fresh cool air. Use artificial respiration, as for drowning (p. 199), if the breathing fails.
Paraffin. Petroleum.	*Induce vomiting.* Apply warmth and friction to the body and limbs. Give teaspoonful doses of spirits and hot water.
Strychnine. Nux Vomica. Vermin Killer.	Give at once 30 drops of Tincture of Iodine in half a tumblerful of water. Then induce vomiting. Then give plenty of strong tea.
Turpentine.	*Induce vomiting.* Then give 1 oz. of Epsom Salts dissolved in half a tumblerful of water. Afterwards give milk and white of eggs freely.

INDEX

Abdomen, wounds in, 174.
Absorption, 62.
Accidents, 161.
Acid, boracic, 68.
— salicylic, 68.
— poisonous, 204.
Adenoid growths, 112.
Adulterated foods, 69.
Air, fresh, 215.
Albumin, 44, 56, 58, 129.
Alcohol, effect of, on plant cells, 23.
— — muscular action, 40.
— — heart, 141.
Alcoholic beverages, 95.
Alimentary canal, 56, 57, 61, 99.
Amoeba, 154.
Apple water, 222.
Arteries, 131, 136, 142.
Artificial respiration, 198.
Auricle, 137.

Baby-plants, 4, 6, 9, 10.
Bacteria, 67, 68, 71, 83.
Ball and socket joint, 27.
Barley, germinating, 9, 98.
Barley grain, 9.
Barley water, 83, 222.
Baths, 209.
Beds, 216, 217.
Bed-sores, 219.
Beef tea, 223.
Beat of heart, 137.
Bean seed, 5.
Beer, 95.
Beverages, 82.
— alcoholic, 95.
— for sick, 221.
Beverages, non-nourishing, 86.
— nutritious, 82.
Biceps muscle, 29, 37.
Bile, 60.
— uses of, 129.
Bites, 189.
Bladder, 127.
Bleeding, 145.
— of head, 164.
— from arteries, 145.
— — eye, 166.
— — lungs, 197.
— — nose, 196.
— — stomach, 197.
— — varicose veins, 173.
— — veins, 145.
— to check, 172.
Blood corpuscles, 133, 134.
Blood-vessels, 70.
— duties of, 130.
Bones, broken, 170, 171.
— growth of, 31.
— structure of, 35.
Boracic acid, 68.
Brain, 149.
Bran poultice, 213.
Bread, 46.
Bread poultice, 213.
Breathing, 101.
— movements of, 107.
— of plants, 15.
Bronchi, 106.
Bronchitis, 119.
Bruises, 167, 174.
Burns, 187.

Caffeine, 94.
Carbohydrates, 45, 46, 48.

Carbon, 14, 42, 45, 47, 50.
Carbon dioxide, 12, 14, 15, 20, 87, 97, 100.
Cartilage, 32.
Capillaries, 131, 132, 133.
Casein, 44.
Cells, 22, 23, 24, 152.
Cerebellum, 149.
Cerebrum, 150.
Charcoal, 14, 42.
Chest, wounds in, 174.
Chicory, 94.
Chocolate, 85.
Choking, 195.
Cleanliness, 218.
Clothing on fire, 186.
Cocoa, 83.
Coffee, 80, 93.
Collar bone, 27.
— broken, 182.
Cold bath, 209.
— sponging, 125.
Colds, 119.
Combustion, 9.
Connective tissue, 36, 54.
Consumption, 120.
Convulsions, 206.
Cooking, 54.
Corpuscles of blood, 133, 134.
Cough, whooping, 208.
Courtesy, 158.
Cotton wool, dangers of, 187.
Curvature of spine, 34.
Cuts, 171.

Delirium, 220.
Diarrhœa, 206.
Diastase, 11, 98.
Diaphragm, 106.
Digestion, 11, 49, 58, 60, 62.
Digestive juices, 59, 60.
Dislocations, 183.
Division of labour, 155.
Draughts, 215.
Drinks, nourishing, 82, 222.
Drowning, 198.
Drugs, 24, 40.

Ears, 167.
Ears, bleeding from, 165.
— foreign bodies in, 191.
— inflammation of, 207.
Education, 157.
Eggs, 49, 50, 52, 53, 223.
Egg lemonade, 223.
Electric shock, 202.
Elements, 42.
Emetics, 208.
Endosperm, 5, 6, 10.
Epileptic fits, 194.
Eustachian tube, 112.
Exercise, 40.
Excretions, 122.
Excretory organs, 123, 128.
Expiration, 105.
Eyes, 166.
— foreign bodies in, 189.

Fainting, 192.
Fermentation, 97, 98.
Filter, 72, 78.
Finger, dislocated, 184.
Fire, to extinguish, 186.
Fish, 52.
Fits, 194.
Flannelette, dangers of, 187.
Food, 46, 51, 56, 61, 66.
Foods, adulterated, 69.
— classes of, 41.
— common, 49.
— storage of, 53.
Fomentations, 213.
Fractures of bones, 176.
Fresh air, 215.
Flowers, 2, 19, 21.

Gastric juice, 59.
Germs, 52, 67, 97, 119.
Germination, 6, 13.
Gluten, 44.
Gymnastics, 157.

Head, injuries to, 164.
Health, duty of preserving, 157.
Heart, 136.
— action of alcohol on, 140.
— — tobacco on, 141.
Hearing, sense of, 112.

Heat stroke, 202.
Hip joint, 30.
— disease of, 207.
Hiccough, 196.
Hot baths, 209.
Human society, 152.
Hydrogen, 42, 43, 44.
Hysterical fits, 195.

Inflammation of ear, 207.
Illness, signs of, 206.
Inorganic, 43.
Inspiration, 105, 108.
Intestines, 57, 60.
Involuntary muscles, 40.

Joints, 27.

Kidneys, 126.

Laburnum seeds, 66.
Lacteals, 62.
Larynx, 113, 114.
Leg, broken, 179.
Lemonade, 221.
Life in plants, evidence of, 2.
Limbs, bones of, 27.
— broken, 180.
Linseed poultice, 210.
Liver, 60, 129.
Lungs, 100, 105, 123.
— bleeding from, 197.
Lymph, 135.
Lymphatics, 135.

Malaria, 118.
Malt extract, 11.
Meat, lean, 47.
Microscope, 22, 67.
Microbes, 52, 53, 54, 67.
Milk, 48, 82.
— rice, 222.
Mineral foods, 43, 45, 65, 83.
— salts, 11.
Mouth, foreign body in, 192.
Muscle, biceps, 37.
— triceps, 37.
Muscles, 36.
— involuntary, 40.
Muscles, voluntary, 39.
Mustard bath, 209.
— plaster, 212.
— poultice, 212.
Myosin, 44.

Narcotics, 151.
Neck, wound in, 173.
Nectar, 18, 19.
Nervous system, 145.
Nerve cells, 145.
— fibres, 146, 147.
Nerves, 145, 147.
Nitrogen, 42, 44, 47, 126.
Nose, injury to, 168.
— foreign bodies in, 192.
— bleeding from, 196.

Oatmeal, 49, 50.
— water, 222.
Organic, 43, 75.
Oxygen, 14, 15, 20, 40, 42, 43, 44, 100.
— in ventilation, 117.
— starvation, 117, 118.
— in blood, 144.

Palm, wounds in, 173.
"Palms" of willow, 17, 18.
Pancreas, 60.
Paraffin on fire, 186.
Patient, how to wash, 218.
Peas, 50.
Pharynx, 112, 114.
Phosphorus, 43.
Pistil, 17, 18, 19.
Plasma, 133, 135.
Plaster, 212.
Pleura of lungs, 106, 107, 119.
Pleurisy, 119.
Pneumonia, 120.
Poisons, 203, 227.
Pollen, 18, 19.
Poultices, 210.
Preservatives, 68.
Proteids, 44, 45, 46, 47, 49, 50, 55, 60, 63, 64, 65, 83.
Ptomaines, 52, 67.
Pulse, 142.

Pulses, 50.
Puddings, milk, 48, 225.

Quilts, 217.

Reflex actions, 148.
Reproduction, 16, 21.
Reservoirs, 80.
Respiration, 101, 104.
— artificial, 198.
Ribs, 27.
— broken, 181.
Rice water, 222.
— milk, 222.

St. Vitus' dance, 207.
Saliva, 58, 59, 65.
Salts, mineral, 11.
Salicylic acid, 68.
Sap of plants, 10, 11.
Scalds, 188.
Seed-leaves, 5, 7.
Seed, of barley, 98.
— bean, 5, 50.
— sycamore, 4.
— wheat, 5, 6.
Seeds, foods obtained from, 10.
Shock, 204.
— electric, 202.
Sickness (vomiting), 194.
Sick, tending of, 214.
Signs of illness, 206.
Skeleton, 25.
Skull, 26.
Skin, 101, 123.
Smell, 110.
Social conscience, 157.
Sores, bed, 219.
Speech, 113.
Spinal column, 26.
— cord, 145, 147.
Spine, curvature of, 34.
Spirits, 95, 98, 193.
Splint, 180.
Sprains, 174.
Spitting, 121.
Springs, 80, 81.
Stabs, 171.
Stamens, 18, 19.
Starch, 10, 45, 63.
— digestion of, 11, 58, 60.
— bath, 210.
Stimulants, 94, 97, 193.
Stings, 189.
Stomach, 59.
— bleeding from, 197.
Stupes, 213.
Sulphur, 43.
Suffocation from gases, 201.
Sunstroke, 202.
Sweat, 123.
Sycamore, 4, 6.

Tannin, 92.
Tea, 90, 91, 92.
Tendrils, 8.
Tendon, 36, 37.
Tepid bath, 209.
Thrift, 157.
Theine, 92.
Tissue, 22.
— connective, 36.
Toast water, 222.
Toe, dislocated, 184.
Tobacco, action on heart, 141.
Tourniquet, 172.
Truthfulness, 158.
Turpentine stupe, 214.

Unconsciousness, 165.
Urea, 126, 128.
Ureter, 127.

Valves of heart, 138.
— of veins, 143.
Varicose veins, 173.
Veins, 131, 136, 143.
— of leaf, 12, 13.
Ventricle, 137.
Ventilation, 116, 117.
Vertebra, 26, 30.
Vertebral column, 26, 27.
Vocal cords, 113, 114.
Voice, 114.
Voluntary muscles, 39.
Vomiting, 166, 194, 206.
— to produce, 205, 208.
relieve, 208.

Warmth of germinating seeds, 8.
Water, 70.
— aerated, 89.
— apple, 222.
— as beverage, 221.
— barley, 222.
— egg, 223.
— oatmeal, 222.
— rice, 222.
— sources of, 76.
Water, toast, 222.
Wheat, bread, 46.
— seed, 5, 6.
Whooping cough, 208.
Willow, reproduction of, 16.
Wine, 95.
Wounds, 168.
— cleansing of, 171.

Yeast, 97, 98.

GLASGOW: PRINTED AT THE UNIVERSITY PRESS BY ROBERT MACLEHOSE AND CO. LTD.

A HEALTH READER. By C. E. SHELLY, M.A., M.D., M.R.C.P., and E. STENHOUSE, B.Sc.

BOOK I. For children of 9 to 10 years of age. **1s.**

CONTENTS OF BOOK I.

LESSON I. The Human Body—II. The Framework of the Body—III. The Muscles and their Work—IV. The Head and its Parts—V. The Trunk—VI. The Arms and Hands—VII. The Legs and Feet—VIII. The Different Postures and Movements of the Body—IX. Work and Play—X. Games and Various Forms of Exercise—XI. Eating: its Use and Abuse—XII. Drinking: Good Drinks and Harmful Drinks—XIII. The Use and Care of the Teeth—XIV. How Food is Digested—XV. The Air Before and After Breathing—XVI. How and Why we Breathe—XVII. The Blood and its Work—XVIII. The Circulation of the Blood—XIX. The Circulation of the Blood (*continued*)—XX. The Skin—XXI. Cleanliness—XXII. Clothing—XXIII. The Brain—XXIV. The Nerves—XXV. Touch, Taste, and Smell—XXVI. Hearing and Sight—XXVII. The Training of the Senses—XXVIII. Growth—XXIX. Fatigue and Rest: Sleep—XXX. Good and Bad Habits.

BOOK II. For children of 10 to 12 years of age. **1s. 4d.**

CONTENTS OF BOOK II.

LESSON I. The Powers of the Human Body—II. The Build of the Human Body—III. Bodily Heat and Energy—IV. Milk: the Nature of Food—V. Cereal Foods: Flour and Bread—VI. Eggs and Meat—VII. Sources of Common Foods—VIII. Yeast and Alcohol—IX. Our Secret Friends and Foes—X. The Preparation and Serving of Food—XI. The Teeth—XII. How Food is Digested—XIII. Beverages—XIV. The Air Before and After Breathing—XV. The Lungs—XVI. How and Why we Breathe—XVII. The Blood and its Work—XVIII. The Circulation of the Blood—XIX. The Circulation of the Blood (*continued*)—XX. The Skin and its Work—XXI. Methods of Ventilation XXII. Cleanliness—XXIII. Dust and its Dangers—XXIV. Clothing—XXV. The Nervous System and its Uses—XXVI. Touch—XXVII. Smell and Taste—XXVIII. Sound and the Sense of Hearing—XXIX. Sight—XXX. The Chief Rules of Health.

MACMILLAN AND CO., LTD., LONDON

Other Works by E. Stenhouse

AN INTRODUCTION TO NATURE STUDY.

By ERNEST STENHOUSE, B.Sc. Globe 8vo. 3s. 6d.

SCHOOL WORLD.—"The course is judiciously selected . . . A very complete index adds greatly to the usefulness of the book, which is sure to be welcomed by a large number of teachers throughout the country."

HEAD TEACHER.—"A very practical and clearly written book, worthy of a place in the reference library, or better still on the teacher's shelf. We strongly recommend the book."

NATURE.—"At last we have a text-book of the right kind, something that we can unreservedly recommend to the teacher, both as a guide to the method he should follow and as a storehouse of instructions concerning the details of experiments within his reach."

With A. T. Simmons

SCIENCE OF COMMON LIFE (EXPERIMENTAL HYGIENE).

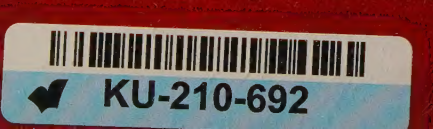
By A. T. SIMMONS, B.Sc., and E. STENHOUSE, B.Sc. Globe 8vo. 2s. 6d.

NATURE.—"The book is well balanced throughout in its treatment of a large variety of scientific facts, and the matter is sound and well selected . . . The book can be confidently recommended. It is of a handy size and well printed and bound."

BRITISH MEDICAL JOURNAL.—"Messrs. Simmons and Stenhouse are to be congratulated upon having well attained the object which they set themselves in this small work. It will serve admirably as a sound practical introduction to the scientific principles which bear upon the subject of hygiene."

JOURNAL OF EDUCATION.—"Messrs. Simmons and Stenhouse's book is very full, and is written with great care and discrimination. The experiments are well chosen and well described, and the pictures given and the apparatus recommended are both very satisfactory . . . The book is a good one."

MACMILLAN AND CO., LTD., LONDON


KU-210-692